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REPORT OF THE COMMITTEE ON A TREATISE ON MARINE ECOLOGY AND PALEOECOLOGY

1950 - 1951

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1950 - 1951

Presented in preliminary form as Appendix A
at the Annual Meeting of the Division
April 28, 1951

* (No. 11 in this Series. See page 83
for list of previous reports)

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REPORT OF THE COMMITTEE ON TREATISE ON MARINE ECOLOGY AND PALEOECOLOGY

INTRODUCTION

During the year the Committee has devoted its time primarily to the assembling and editing of units of the Treatise. Most of these are now in and it is anticipated that the balance will be submitted before the end of the year. The Committee still plans to transmit the completed manuscript to the publisher in 1952, early in that year if possible.

Through a generous cooperative arrangement with the Scripps Institution of Oceanography and the Office of Naval Research Joel W. Hedgpeth is devoting a full year to the Treatise. Mr. Hedgpeth has been designated as editor of Volume 1 (Ecology) and is working closely with Vice-Chairman Gunter. Dr. Roland Brown will continue as editor of Volume 2 (Paleoecology) and will make final decisions regarding the format of the Annotated Bibliographies of both volumes.

Dr. T. Wayland Vaughan who was primarily responsible for the formation of the present Committee in 1940 (then known as The Sub-Committee on the Ecology of Marine Organisms) has several times requested that he be permitted to relinquish his Committee membership because of failing eyesight. This year the Committee reluctantly agreed to accept Dr. Vaughan's resignation and Dr. John W. Wells of Cornell University has been appointed to fill the vacancy thus created.

CLASSIFICATION OF MARINE ENVIRONMENTS

While it is obvious from the criticisms which have been made of the preliminary classifications of 1949 and 1950 that a scheme of classification satisfactory to everyone cannot be achieved, we have tried to derive a classification which is reasonably free of ambiguity, and which does not impose radically new definitions on old terms. Furthermore, we have avoided the introduction of new terms where possible.

Our reasons for adopting the scheme presented on the accompanying diagram are best presented by discussing each term in order.

Benthic: We have attempted to incorporate three environmental factors in this classification: habit of life, that is either swimming or floating in water, or bottom living; distance from shore; and depth of water. The primary division is based on the first factor, and we have used two terms: benthic (bottom dwellers), and pelagic for swimming (nekton), and floating (plankton) organisms.

Supratidal: We have in mind a broader environment than that immediately within influence of spray and storm tides. Salt marshes belong in this environment. A typical dweller in the supratidal environment is the ghost crab (Ocypode) which must reach salt water to breath and shed its eggs, although it may live in a burrow a quarter mile from shore.

Neritic: This term was coined by Haeckel as a complimentary word to Oceanic and accordingly we have used these two terms to indicate a division into near shore and high seas regions.

Intertidal: This is the uppermost part of the neritic or near shore region and is the one term in the series which defines itself. Some workers prefer to use "littoral" as equivalent to "intertidal", but it must be borne in mind that the literature of geology and paleontology is full of references in which the term littoral has been construed much more broadly.

Middle neritic and lower neritic: The intertidal ecologist, with his feet on shore and his province limited by his ability to withstand a moment's submersion, looks upon the next zone out of arm's reach, as the subtidal. Some oceanographers and paleontologists consider the zone of attached algal growth and massive coral growth to be the inner part of the continental shelf. But in some parts of the world, e.g., the Pacific Coast of North America, the entire continental shelf is very narrow, and off fjord coasts, it may be entirely missing. We prefer to use the more general terms middle neritic and lower neritic to divide the near shore environment below the low tide line into two depth zones. The lower limit of the lower neritic zone is variable but we consider it best to indicate it as occurring in most places between 100 and 200 meters.

Oceanic: See neritic.

Bathyal: This term applies to the bottom life of the slopes from 100-200 meters down to somewhere between 2000 and 4000 meters. Our present knowledge is inadequate to justify greater precision.

Abyssal: Below 2000-4000 meters is the true deep sea benthic zone.

Pelagic: See benthic.

Neritopelagic: This refers to the environment of the shallow seas over the continental shelf or near coast. In a region like the North Sea, subject to intrusion of oceanic water masses, this environment may be governed by proximity to land rather than by the depth of the water.

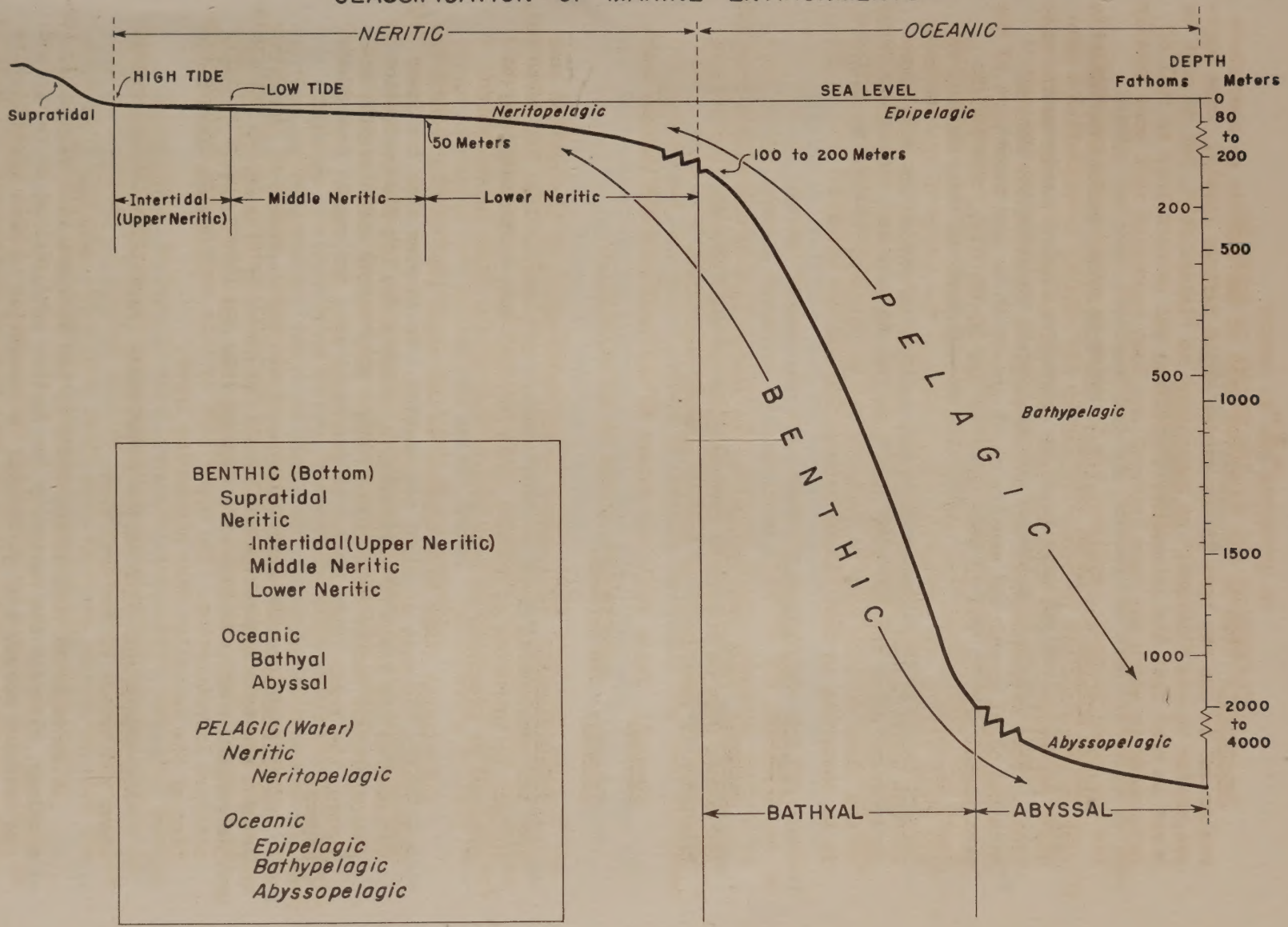
Epipelagic: This term applies to the upper part of the oceanic region within the zone of light penetration. We propose that its lower limit be taken as the depth of compensation, below which organic production by photosynthesis cannot take place. Since this varies with latitude and season, the lower limit cannot be precisely set, but ranges from 80-200 meters.

Bathypelagic: The intermediate, or mid-water, region of the ocean, between the epipelagic region 1000 and 2000-4000 meters, is the bathypelagic region. Here are found the strange deep sea fishes and many highly modified invertebrates. The upper part of this zone is the daytime location of the so-called deep scattering layer.

Abyssopelagic: This is the environment below 2000-4000 meters and above the bottom of the deep sea.

It is expected that contributors to the Treatise will adopt this terminology, although the necessity for further subdivisions is recognized for detailed accounts of particular environments. A more comprehensive discussion of terminology and schemes of classification will be included in the Treatise.

CLASSIFICATION OF MARINE ENVIRONMENTS



BENTHIC (Bottom)
- Supratidal
- Neritic
  - Intertidal (Upper Neritic)
  - Middle Neritic
  - Lower Neritic
- Oceanic
  - Bathyal
  - Abyssal

PELAGIC (Water)
- *Neritic*
  - *Neritopelagic*
- *Oceanic*
  - *Epipelagic*
  - *Bathypelagic*
  - *Abyssopelagic*

CURRENT ACTIVITIES

NEW JOURNALS

Within the year three new journals, devoted entirely or in large part to marine biology, have appeared:

Australian Journal of Marine and Freshwater Research. Published by the Commonwealth Scientific and Industrial Research Organization, Melbourne. Editor: Dr. N. S. Noble. Vol. 1, No. 1 was published April, 1950; No. 2 in December. There is no set date of issue, publication depending on material.

"a medium for the publication of the results of original investigations on sea, estuarine, and freshwater fisheries and cognate subjects."

Boletim do Instituto Paulista de Oceanografia. Publ. by Instituto Paulista de Oceanografia, Sao Paulo, Brasil. Edited by W. Besnard and J. Paiva Carvalho. (Tomo 1, Fasc. 1)

The first issue was published in June 1950, and includes papers on estuarine hydrology, plankton, hydroids, fish, etc., and a short section of reviews, "Livros e revista."

Bulletin of Marine Science of the Gulf and Caribbean. Published by the Marine Laboratory of the University of Miami, Coral Gables, Florida, Robert H. Williams, editor.

Vol. 1, No. 1 appeared March, 1951, and consists entirely of biological papers.

IN THE UNITED STATES

Joel W. Hedgpeth reports that on May 10-12, 1951, a marine borer conference was held at Port Hueneme, California, under the auspices of the U. S. Navy's Civil Engineering Research and Evaluation Laboratory. Several papers of general ecological interest were given, on such topics as the influence of salinity on borers, commensals and predators of Limnoria, and various life history and distributional observations. The meeting was attended by biologists and naval engineers from various parts of the United States and Hawaii. It is hoped to make the conference a regular, possibly biennial, affair. The proceedings are to be published in mimeographed form at an early date.

Pacific Marine Station, Dillon Beach, California, a branch of College of the Pacific (Stockton), completed its fourth regular summer season in August 1951. The station is open to qualified investigators on a year round basis and offers unique opportunities for diversified studies in marine ecology. (See Report No. 2, 1942, pp. 18-19, for an example.) It has an excellent reference collection of marine invertebrates, thanks primarily to the work of Dr. Robert J. Menzies who was museum curator for several years. Dr. Menzies has published a number of papers on northern

California Isopoda, based primarily upon these collections. Two of these appeared in Proc. U. S. National Museum; another in the Wasmann Journal of Biology, a journal published by the University of San Francisco devoted to general biology with some emphasis on the marine fauna. Joel W. Hedgpeth has recently published in this journal a paper on the Pycnogonida of Dillon Beach, including the description of a species living interstitially in coarse sand.

A detailed study of the coral beds in the Middle Devonian Hamilton shales of central New York has been completed by William A. Oliver, Jr., of the Department of Geology, Cornell University, and results will be published shortly.

Three coral biostromes are recognized, two of which are of special interest because of their great size and numerous good exposures. The lower of these, called the Staghorn Point submember by Burnett Smith in 1935, averages about four feet in thickness over at least 150 square miles and is elongate in an east-west direction. The upper bed is much thicker - up to 50 feet in places - but covers only about 40 square miles. No reef structures are present and the beds, with an exclusive rugose-tabulate coral thanatocoenose, are the remains of dense coral growth on shoal banks in a somewhat muddy sea. Growth-forms of the tabulates suggest shallower, more agitated water for the upper coral bed. The lower bed rests on a heavy sandstone "platform", which evidently was clean enough for coral colonization, perhaps due to proximity to wave base. The upper bed has no such basal structure, but apparently obtained its start on a vast low thicket of the colonial coral, Eridophyllum, whose branches afforded settling sites for solitary rugose planulae. The coral faunas of both beds are essentially similar, consisting mostly of solitary species of Siphonophrentis, Heterophrentis, Bethanyphyllum, Heliophyllum, and Cystiphylloides, in incredible numbers and excellent preservation in a shale matrix, together with occasional colonies of Eridophyllum, Prismatophyllum, and Favosites, with very rare small colonies of stromatoporoids. These genera are all either wholly absent from or extremely rare in the Hamilton of this region. On the other hand, the little rugose coral, Stereolasma, which is a common and characteristic pelophile of the upper Hamilton, is very rare in the coral beds. Faunistically, the coral bed fauna is the well-known Onondaga-Columbus limestone bioherm-biostrome coral fauna, modified for a less favorable situation.

Gulf Coast Marine Laboratories. There are now eight marine laboratories on the Gulf Coast of the United States. These are: The Oceanographic Institute of Florida State University at Alligator Harbor; the Fish and Wildlife Service Laboratory at Pensacola; the Alabama Department of Conservation Laboratory at Bayou la Batre; the Gulf Coast Research Laboratory at Ocean Springs; the Texas A. & M. Research Foundation Laboratory at Grande Isle, Louisiana; the Louisiana State University Marine Laboratory at Grande Isle; the Texas Game, Fish and Oyster Commission Laboratory at Rockport; and the Institute of Marine Science of The University of Texas at Port Aransas.

The Florida State University Laboratory and the Gulf Coast Research Laboratory are new and have been devoted almost entirely to teaching, as has the Louisiana State University Marine Laboratory for many years. The Fish and Wildlife Service Laboratory at Pensacola and the Texas A. & M. Research Laboratory at Grande Isle have been devoted mostly to experimental and parasitological work on oysters. Much ecological work was done at the latter but none has been published for it was connected with litigation and is still classified. The Alabama laboratory is new.

The Institute of Marine Science is devoted to both teaching and research. During the past year publications were issued on the distributions, seasonal cycles, movements and relations of the larger invertebrates, to salinity, descriptions of Texas jetty faunas, and hydrography of the Texas bay system. Unpublished work of the year concerns a survey of the distribution of fishes, crustaceans and mollusks of the Western Gulf from Louisiana to Campeche, taken in shrimp trawls; the ecology of Donax or coquinas on Texas beaches; the setting of fouling organisms at various depths up to eight fathoms off the Louisiana coast, and a study of catastrophic mortality of marine organisms in Texas bays caused by the freeze of January, 1951, which was the most severe in 70 years. - G. Gunter.

Dr. Orville L. Bandy of the University of Southern California has completed his study of the Foraminifera collected from the Gulf of Mexico in 1947 by the U. S. Geological Survey - Office of Naval Research gravity expedition in the area south and southeast of the mouth of the Sabine River (Annual Report of this Committee, No. 9, p. 5). Dr. Bandy plotted frequency distribution against changes in depth, temperature, chlorinity and median grain size of the sediments, finding marked faunal zonation. Temperature appeared to be a factor of little importance in explaining faunal differentiation, salinity was found to be of importance in nearshore environments but there was no apparent correlation between median grain size and faunal trends.

H. S. Ladd of the U. S. Geological Survey has completed a report on dredging operations carried on in the coastal waters of Texas immediately northeast of Corpus Christi. The study revealed the presence of a number of distinct faunal facies, the distribution of which appears to be controlled primarily by salinity and secondarily by type of bottom and other ecologic factors. Shelled mollusks are an important constituent in all facies and are given special attention. Foraminifera obtained during the dredging have been studied by Rita Post of the Geological Survey. Both reports will be published by the Institute of Marine Science.

Under the auspices of the Fish and Wildlife Service a symposium volume designed to summarize our present knowledge of the geology, oceanography and marine biology of the Gulf of Mexico is nearing completion. Most of the major chapters, with bibliographies, are now in the hands of the editor, Dr. Paul S. Galtsoff, and completion is anticipated by the end of the year. Funds have been allocated by the Fish and Wildlife Service for the publication of the symposium in book form.

The Scripps Institution of Oceanography has started a long-term study of marine sedimentology in the northern Gulf of Mexico. The work, which is directed by Dr. Francis P. Shepard, will be supported by the oil industry through the American Petroleum Institute. The Woods Hole Oceanographic Institution and several Gulf Coast institutions are expected to assist Scripps in the program.

Louis E. Conant, Wilbert Hass and Vernon E. Swanson of the U. S. Geological Survey have prepared a comprehensive report on the Chattanooga shale and related rocks of the central Tennessee area. It contains descriptions of conodonts and other fossils found in the shale and an interpretation of the environmental conditions under which the shale was laid down.

Dr. Norman D. Newell is continuing his work on the Permian reefs of West Texas under the auspices of the Humble Oil and Refining Company. He has completed a manuscript on the paleoecology of reefs in the Guadalupe Mountain that will be published as a chapter in volume 2 of the Treatise on Marine Ecology and Paleoecology. In order to obtain data that could be used in interpreting ancient reefs Newell and his party studied the Andros Island barrier in the Bahamas and, as noted in the list of recently published papers, have already described some of their findings.

OUTSIDE THE CONTINENTAL UNITED STATES

At the Arctic Research Laboratory at Point Barrow, Alaska, field work in connection with the survey of marine invertebrates was terminated in September, 1950 because of the ill health of the principal investigator, Prof. G. E. MacGinitie. Professor MacGinitie has returned to California and is now devoting part of his time to the preparation of a final report; Mrs. MacGinitie is studying the mollusks collected during the survey. L. R. Freese has started a comprehensive study of the diatom flora in the vicinity of Point Barrow.

The Scripps Institution of Oceanography is continuing its program of oceanographic exploration of the North Pacific Ocean, initiated last year by the joint Scripps-U. S. Navy Electronics Laboratory Mid-Pacific Expedition. The Institution's research vessel HORIZON left San Diego on July 27, 1951 on a 2½ months voyage to the northeastern North Pacific and the Gulf of Alaska. The expedition, under the leadership of John D. Isaacs and Warren Wooster, is called "Northern Holiday" because much of the area of operations has not previously been visited by ships equipped for scientific exploration. Other senior scientists on board are Dr. H. W. Menard of the U. S. Navy Electronics Laboratory and Dr. W. Riedell, Australian specialist on pelagic radiolaria. Projects of special ecologic interest include extensive use of the large mid-water trawl developed by Mr. Isaacs for sampling animal populations in the deep-scattering layer and at greater depths in the bathypelagic and abyssopelagic zones; dredging and topographic surveying of many flattopped seamounts in the Gulf of Alaska; collection of closely spaced cores in the belt of radiolarian and diatomaceous ooze which lies south of the Aleutian Islands, in order to study lateral and vertical variations in the radiolarian components of the sediments; detailed surveys

of the 3,000 foot high Mendocino Escarpment that separates the bottom of the Gulf of Alaska from the deeper area to the southward; measurement of currents, temperature, salinity, oxygen and plant nutrients in the waters of the northeastern North Pacific.

Professor Claude E. ZoBell of the Scripps Institution is participating in the Danish Deep Sea Expedition in the western tropical Pacific on board the research ship GALATHEA. He reports that he has found living bacteria of several different types in the deep waters and ocean bottom sediments off the Philippines, at depths of over 34,000 feet.

Dr. Robert W. Hiatt, Director of the Hawaii Marine Laboratory, states that a large number of research projects are now being actively carried on, some at the Waikiki Laboratory, others at the Coconut Island Laboratory in Kaneohe Bay. Among those that deal primarily with marine ecology are the following: Marine ecology of Arno Atoll, Marshall Islands by R. W. Hiatt and D. W. Strasburg; Marine ecology of Onotoa Atoll, Gilbert Islands by A. H. Banner, D. W. Strasburg and J. H. Randall; The comparative ecology of two solarian blennies in Hawaii by D. W. Strasburg; and The biology and ecology of Virginia oysters in Hawaii by J. L. Yount.

The Pacific Science Board of the National Research Council is continuing its program of research on coral atolls, with financial assistance from the Office of Naval Research.

"The field study will follow the pattern of the ecological investigations of Arno in the Marshall Islands instituted last year by the Pacific Science Board with a team of 12 specialists. For comparative purposes the Gilbert Islands have been selected as the site for study this year. The site chosen is a heavily populated, dry atoll in contrast to the wet lush atoll investigated in the Marshalls. The six-man scientific team will leave Kwajalein 15 June on a scheduled trip of the U. S. Coast Guard vessel 'Nettle' and will be landed with full equipment on Onotoa in the southern Gilberts where they will spend 3 months in a general ecological study of the inter-relationships of all forms of life including the native population to their limited environment.

"Dr. Preston Cloud, geologist, U. S. Geological Survey, is leader of the expedition. Other members are Dr. Albert Banner, marine zoologist, University of Hawaii; Dr. Ward Goodenough, anthropologist, University of Pennsylvania; Dr. Edwin T. Moul, land ecologist, Rutgers University; Donald Strasburg, marine zoologist, University of Hawaii; John E. Randall, Jr., marine zoologist, University of Hawaii.

"A follow-up study on Arno atoll in the Marshalls is also being sponsored by the Pacific Science Board, starting in June. Harry Uyehara, anthropologist, University of Hawaii, and Leonard Horwitz, algologist, University of Minnesota, will undertake the investigations there. This project is also being financed by the Office of Naval Research with cooperation from the Navy and the Department of Interior."

The U. S. Geological Survey, in cooperation with the Corps of Engineers, U. S. Army, is continuing the program of mapping in the Pacific Islands, under the leadership of Sherman K. Neuschel who reports as follows:

"Geologic mapping of Tinian, Mariana Islands, by a party headed by Harold W. Burke was completed in March 1951, and soils mapping by Carl Stensland was completed in June 1951. Geologic field work started on Guam in March 1951.

"In the geologic mapping of Tinian, ecological facies of rocks called the Marianas limestone, and regarded as Pliocene to Recent in age, were identified and mapped. Two principal facies were recognized, detrital and constructional. The constructional facies was differentiated into limestone in which corals composed more than 40% and limestone composed mostly of algal material with less than 40 percent corals. Because of an insufficient number of exposures, facies mapping of the older limestones could not be done. Mr. Burke emphasizes that the various facies grade into each other and that the boundaries drawn between facies are arbitrary. The ecology of the modern reefs was studied to aid in the interpretation of the ecological facies of the older reef limestones. Reports on Tinian are now in preparation.

"The work on Guam will require about two years. It will include detailed geologic mapping, soils mapping, an ecological study of the reefs, and special studies of the volcanics. The work is under the direction of Joshua I. Tracey, Jr., who brings to the project his background of study of the reefs of Bikini. A long-range groundwater investigation by the Water Resources Division, U.S.G.S. is included in the Guam project. Facies mapping will be done on Guam and the other Mariana Islands.

"A geologic, botanical, and soils reconnaissance in the Marshall Islands is being planned. Islands in the group are too numerous for intensive studies of the type usual under the Geological Survey mapping program, but, by accompanying a U. S. Army Corps of Engineers party which is establishing geodetic control, an opportunity will be provided to visit numerous islands otherwise difficult of access. Considerable stress will be placed on assembling data relative to the various factors which affect the development of atolls.

"Helen L. Foster continued work on the annotated bibliography of geologic and soils literature on Taiwan, the Caroline, Marshall, Ryukyu, Bonin, Mariana, and Izu Islands. When completed, the bibliography will contain between 2,500 and 3,000 references, including all available literature written by Japanese scientists on the paleoecology and related geologic subjects of these areas. About 1,300 of the references are on Taiwan alone. Approximately 1,400 references have been annotated and the rest will be annotated before June 1952. Only a few strictly paleoecological papers by Japanese authors have been located but related subjects such as paleontology, stratigraphy and coral reefs are well represented. Relatively few papers are in English, but the more important ones written in Japanese have been or will be translated into English.

"A comprehensive report on the geology and soils of Saipan in being prepared under the general direction of Preston E. Cloud, Jr., for publication as a Professional Paper of the U. S. Geological Survey. It will include discussion of the general geology, soils, economic geology, and water resources, and a systematic study of fossil collections. Field work was done on Saipan during 1948 and 1949. Sections on fossil and Recent invertebrates and algae will be prepared by J. W. Wells, W. S. Cole, J. H. Johnson, Julia Gardner, C. W. Cooke and H. B. Stenzel.

"J. Harlan Johnson has been studying calcareous algae in limestones collected from the Pacific Islands at the Colorado School of Mines. Dr. Johnson will continue a special field study begun in 1949 during the summer of 1951. He will study the ecology and distribution of calcareous algae, their importance in the formation of limestones and in the building of ancient and present-day reefs. Collections for further laboratory study will be made. He plans to work on Guam, Rota, Tinian, and Okinawa.

"F. Raymond Fosberg, botanist, now of the Pacific Geological Survey Section, Military Geology Branch, with headquarters in Hawaii, is engaged in a broad project of studies of Pacific vegetation. It includes compilation of three annotated and indexed bibliographies, "Bibliography of Micronesian Botany", "Bibliography of the Vegetation of the Tropical Pacific Islands", and "Bibliography of the Terrestrial Aspects of Coral Atolls". The last mentioned bibliography is of particular interest to ecologists because it includes geography, land geology, climate, water supply, vegetation, flora, fauna, economic plants and animals, ecology and agriculture for all coral atolls and low islands not immediately adjacent to high islands or continental land masses. Other phases of the project include detailed studies of Micronesian vegetation and preparation of descriptions and lists of the flora. For instance, a general description of vegetation of sea-level coral atolls, which emphasizes the basic pattern of vegetation and correlates it with the substratum, salinity and ground water conditions, is being written. Regional differences in vegetation and the causes for those differences are considered.

"Detailed hydrologic measurements were made during the past year on Angaur Island where an intensive study is being made of the characteristics of the Ghyben-Herzberg lens on an oceanic island. Investigations were begun in December 1949 by Chester K. Wentworth of the Honolulu Board of Water Supply and Arnold C. Mason and Dan A. Davis of the U. S. Geological Survey. Saline lakes responding to tidal fluctuations provide unusual ecologic environments. Observations made at test holes also furnish information on the extent of saline encroachment away from the lake shores.

"Allen H. Nicol, engineering geologist, recognized a practical need and use for ecological studies in connection with a project which required a detailed knowledge of subsurface conditions. Core drilling failed to provide necessary information and geophysical investigations were inconclusive. Mr. Nicol believes that detailed ecological studies integrated with stratigraphic data, so that the complete past history of the limestones could be determined, would aid in interpreting subsurface conditions in the area.

"Helen L. Foster is mapping the distribution and studying the characteristics of the ejecta from Mt. Fuji. A study of such recently-deposited volcanic material may aid in the interpretation of highly weathered and poorly exposed volcanics which occur on the Pacific Islands. Neither the marine nor the terrestrial ecological relationships of volcanics have yet been studied on the islands because of the difficulties of interpretation, but more detailed volcanic investigations are planned for Guam."

During the past year additional drilling was done in the Northern Marshall Islands by the Geological Survey in cooperation with the Office of Naval Research. H. S. Ladd states:

"On Eniwetok Atoll two holes were cored on the seaward reef flat bordering one of the windward islands, and two others were drilled on one of the rock groins that extends seaward on the flat. One of the two reef flat holes was located only 475 feet from the seaward edge of the reef. In all 4 of these holes an average of over 50 percent of hard limestone was recovered to depths ranging from the surface to 14 feet. This rock is composed of Foraminifera, algae, corals, and other reef organisms all fresh in appearance with their original color patterns clearly shown. The rock, though containing some cracks and cavities that absorbed much of the drill water, was on the whole hard and compact, and it appears that the wave resisting seaward margin of the reef in some areas is continued lagoonward as a rigid plate.

"On Eniwetok a total of 18 other shallow holes were drilled to depths up to 200 feet. These holes were cored almost continuously using a diamond bit on the harder parts of the section and a Dames and Moore sampler on the softer material. The holes were widely spaced on 6 islands on the windward side of the atoll and penetrated a section of sand, gravel, sandstone, conglomerate, and large massive coral heads. The hardest beds were those close to the surface in the "beachrock belt." Beds of this type were found in every hole except one. The beachrock, in fact was the only recognizable unit that appeared to have any lateral extent. Some of the massive coral heads were several feet in thickness. The cores give a fairly good overall picture of the section immediately underlying the islands and it is apparent that most of the beds were deposited under lagoonal conditions rather than as a part of a rigid, wave-resisting seaward reef. On the whole the section contained a higher percentage of hard or indurated rock than that of Bikini to the east but no other very important differences were noted.

"One hole was put down on Eniwetok to a depth of 1,285 feet. The major zones encountered may be correlated with those of Bikini though they appear to occur somewhat higher at Eniwetok."

In reporting on current activities of Japanese geologists and paleontologists, Doctors Shoshiro Hanzawa and Kotora Hatai of Tôkoku University include the following:

"Wataru Ichikawa of Kanazawa University has been studying the Neogene diatom flora from the Prefectures of Ishikawa, Toyama and Niigata in the hope of interpreting paleoecological and paleothermal conditions under which the diatom-bearing strata were formed. He is now working on the diatoms washed from cores from wells drilled down to a depth of 400 meters near the Kahoku lagoon in Ishikawa Prefecture and attempting to determine their relation to the sedimentation, paleoecology and paleo-oceanographical conditions. His preliminary study of this new project indicates that at a depth of 300-400 meters the diatoms are marine, but above 300 meters they are fresh and brackish water. He also maintains that 300 meters is the critical point for the boundary between the Tertiary and Quaternary deposits.

"Yokichi Takayanagi of Tohoku University is planning a comparative study of the Recent Foraminifera from Kushiro and the fossil Foraminifera of the adjacent Tertiary formations of the Kushiro coal field of Hokkaido. This comparative study is based upon biologic analyses of the ecology, oceanographic conditions and bottom sediments of the Recent species and their relation to the fossils.

"D. Miyadi and T. Habe are working on the biocoenoses and thanatocoenoses of bays, basing their works chiefly on the molluscan shells; Y. Ishiwada published on the death assemblages of Foraminifera in the Toyama Bay, and M. Morishima and others have contributed to the ecology of the foraminifers of the Inland Sea and some bays along the coast of the Japan Sea."

The second meeting of the Indo-Pacific Fisheries Council was held at Cronulla, New South Wales, from April 17th-28th, 1950. In addition to the sessions devoted primarily to fisheries biology and technology, a symposium session on estuarine problems was held. The papers given at this symposium have been published as Section III of the 1950 Proceedings of the Council (Bangkok, 1951).

The two Navy oceanographic survey vessels, the USS SAN PABLO (AGS-30) and the USS REHOBOTH (AGS-50), operated under the technical control of the USN Hydrographic Office, continued their survey work in the North Atlantic.

These vessels, since January 1949, have completed a total of eight cruises and are now at sea for cruise nine. Since spring 1950, the ships, during four cruises, have steamed approximately 35,000 miles. Routine oceanographic stations were occupied, usually to a depth of 2,500 meters with occasional stations to 4,000 meters. Temperature, salinity and oxygen measurements are made at each depth sampled. Hourly baththermograph lowerings are made while underway, with routine meterorological data recorded for each lowering.

To supplement the more or less "classic" oceanographic observations, the Hydrographic Office has instituted a program of instrumentation, designed to take full advantage of excellent sea-going capabilities of the two vessels. Emphasis has been placed on continuous recording instruments, permitting uninterrupted records over broad geographical areas.

In part, these new instruments and techniques include the following:

a. Bathymetry. Each vessel is equipped with two 4,000 fathom, recording echo sounders. One instrument is in operation whenever and wherever the vessels are at sea with the other in standby. In areas of particular interest, a detailed grid is run usually with the ships positioned 10,000 yards apart. Position is maintained by radar.

b. Radiation Measurements. One of the vessels is equipped with three Eppley Pyrheliometers; one mounted in the super-structure to measure the incoming solar radiation and the other two mounted port and starboard at the outboard end of a boom to measure the back-scattered radiation from the sea surface. The inboard half of each of the latter two has been blanked-off to preclude picking up the energy reflected from the vessel. In conjunction with the data from these three instruments, these data continuously and simultaneously recorded on a three channel recorder, measurements are made of the light penetration at various depths below the surface of the sea. These measurements, made with a photometer, equipped with discs for measurement at various spectral bands, are calibrated against a standard cell recording at deck level.

c. Bottom Sediments. Using a modified Ewing Piston Corer, cores are taken at intervals during each cruise. The maximum core length thus far was 30.5 feet and the deepest area cored was 2519 fathoms. When the depth of water permits, the Phleger coring tube is used along with various types of grab samplers. Recently, an underwater camera was added to the program, and bottom photographs will be taken in conjunction with the sampling and in other areas of interest.

d. Mid-water Trawl. A mid-water trawl, developed at the Scripps Institution of Oceanography, has been recently streamed from the USS SAN PABLO in an effort to sample the Deep Scattering Layer (Phantom Bottom). This net, maintained at various depths by a specially constructed depressor, is fifty feet in length, constructed with a pentagonal mouth of a ten foot diameter and a cod end. To date, the tows have not been as productive as anticipated but, with increased skill in technique, better results will undoubtedly be achieved.

If additional information concerning the vessels is desired, see "The Navy's Oceanographic Survey Vessels", U. S. Naval Institute Proceedings, Vol. 77, No. 4, Whole No. 578, April 1951.

Timothy B. Bagenal of the Marine Station at Millport in the Firth of Clyde, Scotland, has prepared a brief report on recent activities at British marine stations that have paleoecological significance. This report is given below and to it Mr. Bagenal has thoughtfully added a list of British marine stations with notes on their location, organization, etc. American geologists and biologists planning to visit Europe will certainly find this information useful.

"Little of the British work on marine biology during 1950-51 has any direct paleoecological bearing. However Dr. N. S. Jones of the Port Erin Station, Isle of Man has produced a very useful review of marine community terminology and general concepts. (Biol. Rev. 25) which he later uses in another important paper on the bottom fauna off the South of the Isle of Man (J. Anim. Ecol. 20). Four types of bottom deposit are distinguished (their limits being set by wave action and tidal currents) and each is found to carry a distinctive fauna. Each community, with its variations, is described and finally the fauna as a whole considered on a zoogeographical basis. Comparable work from the Plymouth Marine Station is being undertaken by N. A. Holme. In the Jour. Mar. Biol. Assoc., 29, No. 1 he describes the bottom fauna off the Devonshire coast, using a new sampler he described in 1949 (J.M.B.A. 28, No. 2). The changes in the fauna since the last survey in 1923 are discussed. Later, in the same journal he has given an account of the population dispersion of the lamellibranch Tellina tenuis Da Costa. This aspect of recent marine ecology may well prove to be of very great significance in any quantitative paleoecological investigations.

"From the fishery laboratory at Burnham-on-Crouch E. W. Knight-Jones and J. P. Stevenson have been investigating the special distribution and gregariousness of the barnacle Elminius modestus Darwin (J.M.B.A. 29, No. 2) this work being linked with similar studies in oysters. Work on barnacles is very active in Britain at the present time, letters to 'Nature' coming from Crisp, Bishop and others; while from the Millport Marine Station Barnes and Powell have studied the settlement of barnacles (as well as other groups) on fibre-glass surfaces of different textures (J.M.B.A. 29, No. 2). Studies of this sort are important from the point of view of correlation between species and the sediment in which they occur naturally, and in this connection must be mentioned a paper by Wilson, J.M.B.A. 27, on the relation of the substratum to the metamorphosis of the annelid Ophelia. Barnes and Powell have also investigated the ecological conditions on which the morphology of barnacles is dependent, (J. Anim. Ecol: 19.2) paying particular attention to the effect of overcrowding. Barnes and Bagenal (J. Malac. Soc. in the press) have used epizoic barnacles as habitat indicators for the gastropod Aporrhais pes-pelicani and also for the decapod crustacean Nephrops norvegicus J.M.B.A., (in the press)."

British Marine Biological Stations. The marine biological research stations in Britain are organized by three different bodies, the government, the universities and private societies.

In England the government sponsored laboratories are run by the Ministry of Agriculture and Fisheries, whose main station is at Lowestoft (Director: M. Graham). There are two smaller stations at Burnham-on-Crouch on the east coast, and at Conway in North Wales; both are concerned with oyster and other shell fish research. In Scotland the government laboratories are run by the Fishery Board for Scotland whose station is at Aberdeen (Director: Dr. C. E. Lucas). Naturally the main emphasis at these stations is on fish and fisheries, attention being directed chiefly

to the commercial aspects, and on plankton and hydrography, though some ecological work is done. Both these fishery laboratories have a fleet of research vessels that regularly work in the North Sea and as far afield as Iceland.

Work in the open ocean, particularly on the physical and chemical problems is carried out by the recently formed Institute of Oceanography (Director: Dr. G. E. R. Deacon). This institute has taken the place of the old Discovery organization and it is allied to, though not directly controlled by the British Admiralty.

The research stations sponsored by the British Universities, unlike those of the U.S.A., have always had the weakest organization due, in part perhaps, to the split responsibilities of a professor in charge of two departments. This trouble appears to be being cured as most of the university marine stations are now flourishing organizations, usually under a whole time director. The laboratory at Cullercoats is run by the University of Durham, under Professor A. D. Hobson. Also on the east coast is the Gatty Laboratory run by St. Andrew's University in Scotland. On west coast Liverpool University has a flourishing marine station at Port Erin (Director: J. S. Colman) on the Isle of Man: and since the last war the University of Wales has sponsored a laboratory at Bangor (Director: Dr. Crisp).

Besides the marine stations already mentioned are three run by private societies, although in recent years the government has been providing larger and larger contributions towards their upkeep and maintenance. The best known of these is the Plymouth Laboratory in the English Channel, run by the Marine Biological Association of the U.K. (Director: F. S. Russell) with a permanent staff of 14 scientists. In Scotland is the slightly older Marine Station at Millport in the Firth of Clyde on West coast run by the Scottish Marine Biological Association (Director: E. Ford) with a staff of 10. There is a sister laboratory run by the same Association at Leith on the east coast, which is entirely concerned with plankton studies carried out by the Hardy Plankton Recorder.

Both the Plymouth and Millport stations (although neither have a geologist on their staff) make a point of providing accommodation and service for visiting workers, so that the small amount of geological work done at these stations is primarily the fault of the geologists; nevertheless the classic work of H. B. Moore on pellet muds was carried out at Millport and Professor W. B. R. King, and Dr. M. N. Hill have recently been investigating the geology and geophysics of the English Channel from the Plymouth Station.

Since the war a station has been opened at Dale Fort in Pembrokeshire, South Wales by the Council for the Promotion of Field Studies (Warden: J. H. Barrett), where a far wider scope of work is encouraged, and although much attention is payed to teaching, research workers are encouraged and offered all available facilities.

The results of work on marine ecology may be published in one of a number of journals. The Plymouth Laboratory publishes the Journal of the Marine Biological Association in which most of their work appears. Papers from the other stations may also be in the J.M.B.A. or else in the Journal of Animal Ecology, which also concerns itself with non-marine work. More specialized papers may be published elsewhere, such as those on molluscs in the Journals of either the Conchological Society or Malacological Society. The Hull Bulletins on Marine Ecology are almost exclusively concerned with plankton work.

Scientific meetings on marine ecology are organized not only to a limited extent by the British Ecological Society but also by the Challenger Society. This society does not issue any publications but exists solely for the organization of semi informal meetings discussing current activities. The Ray Society on the other hand does not hold any meetings and its sole aim is the publication of monographs on the British fauna and flora - the main emphasis being on marine life.

RECENTLY PUBLISHED PAPERS

Most of the papers below appeared after May 1, 1950.

GENERAL

Adams, John Emery and Frenzel, Hugh H.
Capitan Barrier reef, Texas and New Mexico: Jour. Geology, vol. 58, no. 4, pp. 289-312, 1950.

Anderson, Charles A., et. al, 1940, E. W. Scripps Cruise to the Gulf of California: Mem. 43, Geol. Soc. America, 1950.
Part I. Geology of islands and neighboring land areas by Charles A. Anderson, pp. 1-58.
Part II. Megascopic paleontology and marine stratigraphy by J. Wyatt Durham, pp. 1-216.
Part III. Submarine topography by Francis P. Shepard, pp. 1-32.
Part IV. Pleistocene and Pliocene Foraminifera by M. L. Natland, pp. 1-55.
Part V. Sedimentation and oceanography: survey of field observations by Roger Revelle, pp. 1-6.

Behre, Ellinor H.
Annotated list of the fauna of the Grand Isle Region: Occasional Papers Marine Lab., Louisiana State Univ., No. 6, 66 pp., 1950.

Faunal list, with various ecological notes; also lists plants of the area. Short bibliography is included.

Berrill, N. J.
The Living Tide: New York: Dodd, Mead, 256 pp., illus. 1951.

Popular account of work at seashore and habits and peculiarities of seashore life.

Besnard, W.
Considerações gerais em tôrno da região lagunar de Cananéia-Iguape. I: Bol. Inst. Paulista Oceanografia, vol. 1, No. 1, pp. 9-26, 12 figs., map, 1950. (General considerations of the lagunal region in the vicinity of Cananéia-Iguape) Part I of a series; this concerns physical description and origin of the region. (Joel W. Hedgpeth)

Birstein, J. A.
Poniiatie "relikt" biologii: Zool. Zhurnal, vol. 26, no. 4, pp. 313-330. 1947. (The conception of "relics" in biology.)

Relics are of three varieties: taxonomic, ecologic and geographic, are characterized primarily by a slow evolutionary rate and other characterisitcs follow as a result of the slowing down of evolution.

Three categories of relics are proposed: 1. local, the remnant of a more extensive distribution; 2. refugial, adapted to a special habitat; and 3. defensive, having developed means of passive protection. (From Engl. summary.)

Boden, B. P.
Plankton organisms in the deep scattering layer: U. S. Navy Electronics Laboratory, Report No. 186, pp. 1-29, June 1950.

Bond, Geoffrey
The Lower Carboniferous reef limestones of northern Ireland: Jour. Geology, vol. 58, no. 4, pp. 313-329, 1950.

Extensive bibliography.

Bradley, John S.
Upper Cretaceous-Eocene(?) Nanaimo group of the San Juan Islands, Washington (abstract): Bull. Geol. Soc. Amer., vol. 61, no. 12, pt. 2, p. 1520. 1950.

Carson, Rachel L.
The Sea Around Us: New York: Oxford University Press, 230 pp., illus. 1951.

A well written summary of modern oceanography for laymen.

Caspers, H.
Der Biozönose - und Biotopbegriff von Blickpunkt der marinen und limnischen Synokologie: Biol. Zentralb., vol. 69, nos. 1-2, pp. 43-63, 1950.

An examination of terms and concepts in marine ecology; the basic term is the biocoenosis of Moebius. The problem is to determine the limits of the biocoenosis. For example, a lake is a single biocoenosis although it is contained within the greater whole, the land. (Joel W. Hedgpeth)

Caspers, H.
Biozönotische Untersuchungen über die Strandarthropoden im bulgarischen Küstenbereich des Schwarzen Meeres: Hydrobiologia, vol. 3, no. 2, pp. 131-193, 15 figs. 1951.

A general account of the fauna of Bulgarian beaches with particular reference to sandy beaches and the insect fauna. The zonation of rocky beaches is also described. Two principal divisions are recognized in the sandy beach, the dry sand, which is a part of the terrestrial biocoenosis system, and the damp sand, which is marine in character. The paper is of interest in providing a description of zonation on a rocky seacoast where salinities are around 17 o/oo and tidal range is very small. (Joel W. Hedgpeth)

Caspers, Hubert

Quantitative Untersuchungen über die Bodentierwelt des Schwarzen Meeres im bulgarischen Küstenbereich: Archiv Hydrobiol., vol. 45, pp. 1-192, 66 figs., 7 pls., 1951.

The results of studies carried out from 1939-41 in Varna Bay, Varna See and the Gebedsee, a gradient system of bays connected by canals from the Black Sea to nearly fresh water, are discussed. Field data are based primarily on bottom samples made by the Petersen grab. The salinity, temperature and O_2 regimes, sedimentation characteristics and the communities of bottom invertebrates are described. There is also a list of the animals found in the region. Growth curves for the more important bottom organisms, e.g. Cardium edule and Venus gallina, are presented. The communities are recognized primarily on the basis of substrate, with subdivisions into zone and variation. In the author's usage the term "Gemeinschaft" which is approximate to the American "association" is treated as equivalent to biocoenose. A reduction in number of species following the salinity gradient from the Black Sea to the Gebedsee is observed. The bays have not been isolated from the sea long enough to contain relict species. The paper presents a large amount of interesting information about a region little known to marine and estuarine ecologists in other parts of the world. (Joel W. Hedgpeth)

Chenoweth, Philip A.

Trentonian paleogeography in northwestern New York, (Abs.): Bull. Geol. Soc. Amer., vol. 61, no. 12, pt. 2, p. 1450, 1950.

Collier, Albert and Hedgpeth, Joel W.

An introduction to the hydrography of tidal waters of Texas: Pub. Inst. Mar. Sci., Univ. Texas, vol. 1, No. 2, pp. 125-194, 1950.

The Aransas Hydrographic System, a part of the shallow coastal lagoon and back bay complex of the tidal waters of Texas, and its contributing drainage area, is described. The total area of bays concerned is roughly 750 sq. mi., and the land drainage area is about 30,000 sq. mi. This system is connected with the Gulf of Mexico through Aransas Pass, an artificially deepened and jettied inlet near the center of the Texas coast. The lower part of this drainage area lies in the semi-arid climatic zone, the upper part mostly in the dry subhumid, and a small part in the moist sub-humid zone. Rainfall is erratic and shifty over the drainage area, frequently causing floods which reduce salinities in the bays. Annual precipitation in the area concerned is 26-30 in., with high peaks in spring, and in Sept. near the coast. Evaporation exceeds precipitation over the area concerned during most of the year and there is an annual deficit of 25-50 in. from the coast toward the interior. Salinity characteristics are estuarine, ranging from nearly fresh water at the river deltas to more than 30 parts per 1000 in the pass. An exception to this is the Laguna Madre, where salinities are often over 80 and sometimes 100 parts per 1000. The annual temp. range in bay waters is around 25°C, with occasionally greater ranges in yrs. of very cold winters.

The waters are on the whole temperate rather than tropical. Salinity exchange in the bays is more pronounced during the tropical tide periods, which have greater ranges than the equatorial tides. In the Laguna Madre the seasonal rise in sea level is the prime agent in bringing about salinity exchange between that body of water and Corpus Christi Bay. The tide at Port Aransas is of the mixed type, with a regular progression of daily and semi-daily tides. Tides in the bay are similar but somewhat dampened and less in range and amplitude. During the equatorial or semi-daily tides, the tide "vanishes" so that there is a continued stand above sea level. There are pronounced differences in monthly sea level, with higher levels in the spring and autumn months. Wind disturbances affecting tides are of two types: Northers, which set up a diphasic swing in bay levels when their impact is abrupt and forceful, or a continued depression of bay levels if sustained, and hurricanes, which pile up water as high as 15-16 feet in bays to the right of their course. Tables of essential data, including monthly means of climatic and hydrographic factors and physical measurements of the bays, are presented. (J. W. Hedgpeth)

Connell, Cecil H. and Cross, Joy Barnes
Mass mortality of fish associated with the protozoan Gonyaulax in the Gulf of Mexico: Science, vol. 112, pp. 359-363, 1950.

Cooper, G. Arthur
Permian fauna of Glass Mountains of Texas and its ecology, (abs.): Bull. Geol. Soc. Amer., vol. 61, no. 12, pt. 2, p. 1453, 1950.

Crespin, Irene
Australian Tertiary microfaunas and their relationships to assemblages elsewhere in the Pacific region: Jour. Paleo., vol. 24, no. 4, pp. 421-429, 1950.

Dahl, Erik
On the smaller arthropoda of marine algae, especially in the polyhaline waters off the Swedish west coast: Unders Oresund, vol. 35, 193 pp., 41 figs., 1948.

A study of the arthropod fauna of algae especially in relation to salinity characteristics and detritus. Some animal communities dependent on a combination of both factors are found. Marine communities require a salinity of more than 27-28 o/oo and require comparatively stable conditions. Where fluctuation is greater, the lower limit is 30-31 o/oo. A well characterized polyhaline zone is found, but there is no evidence for further subdivision of this zone. The fauna of the uppermost sublittoral is exposed to extreme conditions where tidal fluctuation is slight and winter temperatures are low; such conditions are more favorable to the Halacarida than to truly marine animals. The author discusses in some detail the views of Redeke and Remane on the classification of brackish waters and their fauna. (Joel W. Hedgpeth)

Davis, Charles C. and Williams, Robert H.
Brackish water plankton of mangrove areas in southern Florida: Ecol. 31, no. 4, pp. 519-531, 1 fig., 1950.

A study of 39 plankton samples from 28 mangrove-bordered inland bodies of water in lower southern and western Florida. Salinities from 0.61 to 29.09 o/oo were found. More species were found in the higher salinities and were "more of the oceanic type than those elsewhere." Fresh water types were found in the very low salinities, but bays with intermediate salinities were more nearly like the higher salinity, oceanic type bays in their plankton composition.
(Joel W. Hedgpeth)

Dawson, E. Yale
A further study of upwelling and associated vegetation along Pacific Baja California, Mexico: Jour. Marine Res., vol. 10, no. 1, pp. 39-58, 1951.

Day, J. H.
The Ecology of South African Estuaries: Part 1, A review of Estuarine Conditions in General: Royal Soc. South Africa, Trans., vol. 33, pt. 1, pp. 53-91, text figs. 1-2. June 1951.

The work done by T. A. Stephenson and his colleagues on the Intertidal Fauna and Flora of South Africa during the Nineteen Thirties merited the acclaim with which it was received by ecologists everywhere. He limited his field, however, to "the biota of the South African coast as a whole, between tidemarks." The later Survey initiated and in large part accomplished by former co-workers of Dr. Stephenson, is an extension of the intertidal Coast study into the estuaries and out to sea. Though the first of a series, made after 3 years of estuarine study in South Africa, the present report is complete in itself and is the foundation on which the studies of all the individual estuaries are based. The factors common to all estuaries and those peculiar to South African estuaries are clearly demonstrated.

By dictionary definition, an estuary is that area in a river in which tidal effects are evident. An estuarine population is characterized by its tolerance to changes in salinity. The South African coast has been submerged and still retains some youthful features. Practically the whole length of the coast is subject to the full force of the oceanic swell but the tidal range is rarely more than five feet. Sand bars are commonly thrown across the mouth of a stream resulting in a blind estuary in the dry season and at other seasons, a sheltered lagoon in sharp contrast to the wave beaten rocky shore. The physical action and interaction induced by such an environment is set forth in carefully considered detail, for example, the mechanics of tides and currents when the ocean is pushing in with the rising tide and the lighter river water is attempting to flow out. The sediment pattern in an estuary is a function of the currents and the shape of the basin in which they are contained. Estuaries are usually more turbid than the sea and because of periodic droughts and rapid soil erosion, the

turbidity in South African streams is unusually high. As a rule, the fine muds of the upper reaches grade into coarse clean sands at the mouth. The salinity increases from very low values at the head to about 35 parts per thousand at the mouth. Various minor factors may enter in: the salinity of sediments at few inches below the surface is not the same as that of the overflowing water: when the estuary is closed, the salinity will slowly decrease if the intake of fresh water exceeds the loss by evaporation; or increase if evaporation and seepage through the bar exceed the intake of fresh water. Estuarine temperatures, especially in blind estuaries, are commonly higher than those of the sea and the extremes are to be found at the heads where the proportion of river water is higher. Osmotic control seems to be more effective at high temperatures.

Animals restricted to estuaries are all of them euryhaline. The majority of marine animals are stenohaline but many of them will tolerate passively a limited and slow reduction in the salinity. Very few estuarine animals are of fresh water origin and these are restricted to the slightly brackish waters at the head of the estuary. No peculiar hypersaline fauna has been found and those living in a salinity of 40 to 60 per thousand are merely forms of unusual tolerance. Except in blind estuaries, the fauna is being constantly recruited from the sea. Planktonic larvae are transported by the tides and currents high up into the upper reaches, but the mortality is great and the plankton must be constantly renewed. When estuarine life has become impoverished by a block at the mouth of the stream and the rains come and the stream breaks through to the sea and the sea to the land, the enrichment of the fauna is very rapid and very marked. Stephenson demonstrated that the distribution of the intertidal fauna of the South African coast was governed by the ocean currents and the sea temperatures. Day and his colleagues found that, in a general way, the estuarine faunas were similarly controlled. The marine algae afford the basic food source and they also offer a hard substratum to which animals normally restricted to rocks, may attach themselves; a shelter for countless small animals; and a buttress against erosion by the currents. Zostera is the most important of the algae, especially at or near low tide mark in the more saline areas. Locally, the excessive turbidity and the consequent low penetration of light is a restricting factor in its distribution.

The pattern of the fauna is not fixed or sharply defined but Day has observed the following shifting zones:

1. Head of the estuary: Fresh water forms which can tolerate only a little salt.

2. Upper reaches of the estuary: A meagre fauna of mud-loving estuarine forms, most of them living on the surface of the mud because of the lack of oxygen in the lower layers. Salinity of 5 or 8 to 15 or 20 per thousand.

3. Middle reaches of the estuary: The richest and most varied of the faunal zones, due in part to the rich Zostera pastures. Substratum of sandy mud. Euryhaline estuarine component particularly important where the salinity conditions are severe and competition with marine forms is lowered. Zostera fields at or near low tide level; salt marsh plants at upper level; mangroves in tropics. Mollusca mostly burrowing.

4. Mouth of the estuary: Stenohaline marine component. Clean coars sands, unstable and with a low food value. Salinity rarely below 25 per thousand. Fewer burrowing forms than in the middle reaches; some rock dwellers; oysters common.

The majority of the estuarine herbivores feed on detritus of which Zostera is the most important source. Detritus drifts along in the estuarine currents and is laid down in the quieter areas and eventually buried. While still in suspension, fan worms, the burrowing prawn, Solen, Cardium and Mya feed upon it; when it reaches the bottom, it is the food of shrimps, prawns, musids, Corophium and other amphipods; it is sucked down by the searching siphons of Macoma and Scrobicularia or it is caught in the sticky tentacles of Polychaets and Holothurians. When buried, mud swallowers like Arenicola and sand-sifters like Callianassa use it for food. These detritus feeder are, in turn, devoured by Nemertines, whelks, crabs, starfishes and smaller fish, and these in turn by the larger predaceous fishes and the birds. Day summarized the economy of the estuary by a quotation from Hartley, 1947:

"The essential organization of animal life in an estuary is that of a resident population providing food for a number of migratory predators."

The bibliography which follows is excellent. (Julia Gardner)

Dellow, Vivienne

Inter-tidal ecology at Narrow Neck Reef, New Zealand (Studies in Intertidal zonation 3.): Pacific Science, vol. 4, no. 4, pp. 355-374, 13 figs., 1950.

Descriptive account of the zonation of algae and sessile animals with examination of the problem of critical levels; the principal critical levels were found to be between mean low water of neaps and mean low water of springs (between +1 and +4 feet), and just below the extreme (lowest) high water of neaps (about 8 feet). (Joel W. Hedgpeth)

deOliveira, Lejeune P. H. (see also Report #10 of this Committee, p. 19, as "Lejeune, P. H. de Oliveira")

1. Estudo hidrobiológico das lagôas de Piratininga e Itaipú: Mem. Inst. Oswaldo Cruz, vol. 46, no. 4, pp. 673-718. 5 maps. 1949.
2. Levantamento biogeográfico da Baía de Guanabara: Ibid., vol. 48, pp. 363-391, 19 figs. 1950.

General descriptions of ecological conditions, flora and fauna of the bays near Rio de Janeiro, including accounts of mass mortality associated with peridinian blooms following rains after dry periods, and of diatom blooms without associated mortalities. (Joel W. Hedgpeth)

Dexter, Ralph
Dredging in shallow sea water: Turtox News, vol. 29, no. 3, 4 pp., 1951.

Durham, J. Wyatt
Cenozoic marine climates of the Pacific Coast: Bull. Geol. Soc. America, vol. 61, no. 11, pp. 1243-1264, 1950.

Durham, J. Wyatt
Pacific Basin and Continental Drift (abstract): Bull. Geol. Soc. Amer., vol. 61, no. 12, pt. 2, p. 1522, 1950.

Ellison, Samuel P.
Subsurface Woodford Black Shale, West Texas and southeast New Mexico: Univ. Tex. Bur. Econ. Geol., Rept. Invest. 7, pp. 1-20, 1950.

Emiliani, Cesare
Introduction to a method for determining the physical characters of fossil environments: Jour. Paleo., vol. 24, no. 4, pp. 485-491, 1950.

Epstein, Samuel; Buchsbaum, Ralph; Lowenstam, Heinz; and Urey, Harold C.
Carbonate-water isotopic temperature scale: Bull. Geol. Soc. Amer., vol. 62, no. 4, pp. 417-426, 1951.

Fairbridge, Rhodes W.
Recent and Pleistocene coral reefs of Australia: Jour. Geology, vol. 58, no. 4, pp. 330-401, 1950.

Fox, Denis L.
Comparative metabolism of organic detritus by inshore animals: Ecology, vol. 31, no. 1, pp. 100-108, 1950.

Fuller, J. Osborn
New discoveries concerning the Sharon conglomerate in northeastern Ohio (abstract): Bull. Geol. Soc. Amer., vol. 61, no. 12, pt. 2, p. 1567, 1950.

Geyer, Richard A.
A bibliography on the Gulf of Mexico, Texas: Jour. Sci., vol. 2, no. 1, pp. 44-93, 1950.

Gibson-Hill, C. A., et. al.
Papers on the fauna of the Cocos-Keeling Islands, Bull. 22, Raffles Museum, Singapore, 1950.

Introduction and note on islands by C. A. Gibson-Hill, pp. 7-28.
Corals by John W. Wells, pp. 29-52.
Echinoderms by Austin H. Clark, pp. 53-67.
Mollusca by R. Tucker Abbott, pp. 68-98.
Crustacea by M. W. F. Tweedie, pp. 105-148.
Vertebrates by Norman Marshall, C. A. Gibson-Hill, and G. H. H. Tate.

This volume which includes the above sections and other minor units is a report based on material and data collected by C. A. Gibson-Hill in 1940 and 1941. Many ecologic data on the marine forms are included

Gisin, Hermann
L'écologie: Acta Biotheoretica, vol. 9, no. 1, pp. 89-100, 1949.

Gröntved, Jul
Investigations on the phytoplankton in the Danish Waddensea in July 1941: Meddel. Komm. Danmarks Fiskeri-og Havundersögelser, Ser. Plankton, vol. 5, no. 2, pp. 1-61, Illus., 1949.

Gunter, Gordon
Seasonal population changes and distributions as related to salinity of certain invertebrates of the Texas Coast, including the commercial shrimp: Publ. Inst. Marine Sci., vol. 1, no. 2, pp. 7-51, 1950.

Reports data collected on invertebrates from March, 1941 to Nov., 1942 in Copano Bay, Aransas Bay and the adjacent Gulf of Mexico with a salinity gradient from almost fresh water to pure sea water in a running distance of 40 nautical miles. Approximately 72,000 specimens of invertebrates, chiefly crustacea, were caught. The peneid shrimps, Penaeus setiferus and P. aztecus (mixed with P. duorarum), the grass shrimp, Palaemonetes, the blue crab, Callinectes sapidus, and the sea pansy, Renilla mulleri, were the most common species. Shrimp of the family Peneidae are the predominant invertebrates of Texas coastal waters. The crustacean species were probably taken in numbers more or less proportional to their abundance, but certain others, such as starfish and sand dollars, were probably present in much greater numbers than the catches show. The oyster, Crassostrea virginica, is abundant in large reefs in the bays. The invertebrate population of the bays is made up chiefly of Penaeus setiferus and P. aztecus, Callinectes sapidus, and the grass shrimp, chiefly Palaemonetes vulgaris. Grass shrimp are restricted to the flats and shallows of the bay shores, while the other species are found all over the bays. Most species can withstand high salinities, but many cannot withstand low salinities and therefore the number of species caught in the Gulf was much greater than the number in the bays. The fauna of brackish waters is marine; as the waters become fresher along the salinity gradient, certain invertebrates that cannot tolerate lowered salinities drop out of the picture, but others persist. There is no compensating increase in the number of species by invasion of fresh water species and therefore the number of species in waters of low salinity is low. Many species grow up in the bays during the

warmer months. Certain Gulf species invade the bays in the spring and summer. When the temperature drops in the fall a great part of the population begins to move to or towards the Gulf. Many species leave the bays entirely in winter and, therefore, the number of species in the bay declines. Similarly, certain Gulf species move out to deeper water and disappear. There is also a movement of crustacea away from the shallows near shore in the fall and early winter. The most striking seaward movement is that of the common commercial shrimp. Variations in number in the Gulf largely involved population changes of Renilla mülleri, Penaeus setiferus, Xiphopeneus krøyeri and Callinectes danae. Invertebrates in less salty water usually are of smaller average size than those of the same species in high salinities. In general there is a direct correlation between size and salinity. This is a result of movement during the life cycle of the whole population of a species and is not due to "stunted" or restricted groups. (author's abstract)

Günther, Klaus

Oekologische und funktionelle Anmerkungen zur Frage des Nahrungswerbes bei Tiefseefischen mit einem Exkurs über die ökologischen Zonen und Nischen. in Moderne Biologie: Gestschrift für Hans Nachstsheim; Berlin, pp. 55-93, 24 figs., 1950.

This paper consists of three parts:

1. A statement of the ecological rule of the relative particle-size-requirement (relativen Brockengrössenanspruch), i.e., that the size of the food particles eaten by a predator stands in a certain relationship to the size of the predator although the size of the prey species itself may be somewhat larger, as in the case of the lion-zebra combination. Exceptions to this are the blue whale and anteaters in one direction, and snakes and deep-sea fishes in the other.

2. A discussion of the adaptations of deep-sea fishes for capturing prey as large as or larger than themselves, with special reference to the jaw structures.

3. An "excursion" into ecological terminology, with special reference to terrestrial environments, in which the niche is defined essentially as the summation of environmental factors. This terminology as a whole is summarized in four tables illustrating the hierarchial arrangement of terrestrial communities. In table 4 a more general classification is presented:

Lebenstätten /Environments/	Lebensgemeinschaften /Communities/	Biologisch bestimmte Gansheiten: Holocoene /Biologically determined totality: Holocene/	Gestalt und Verhaltensgemeinschaften /Form and behavior comminities/
Bioregion	Biom	System Bioregion-Biom	Adaptationszone
Biotop	Biocoenose	System Biotop-Biocoenose	ökologische Zone
Biochorion	Choriocoenose	—	ökologische Zone
Stratum	Stratocoenose	—	—
Habitat	(Tierart) /Species/	System Habitat-Tierart=ökologische Nische	(ökologische Nische)

(Joel W. Hedgpeth)

Hardenberg, J. D. F.

Estuarine problems in south east Asia: Proc. Indo-Pacific Fisheries Council, 1950 (III), pp. 175-180, 1951.

Distinguishes between estuarine and stable brackish water types and reviews local problems, especially the peculiar mud bars at the mouths of Indonesian rivers. (Joel W. Hedgpeth)

Hedgpeth, Joel W.

Notes on the marine invertebrate fauna of salt flat areas in Aransas National Wildlife Refuge, Texas: Pub. Inst. Mar. Sci., vol. 1, no. 2, pp. 103-119, 1950.

An ecological survey of the invertebrate food resources of the salt flat area of Aransas National Wildlife Refuge, Texas, was conducted from February to July, 1946. Six stations, 4 on salt flat areas and one in a ditch near the bay and the 6th on the bay shore itself, were established, and collections and observations were made during the third week of each month. 17 species of marine or brackish water invertebrates were collected. A discussion, with life history notes, of each species is presented. The populations of most of these invertebrates are maintained by migrations from adjoining bay areas. Salinities ranged from 2 to 18.6 parts/1000, but there are indications that the salinities in the burrows of burrowing forms are consistently higher. (Joel W. Hedgpeth)

Hesse, Richard; Allee, W. C.; and Schmidt, Karl P.
Ecological Animal Geography. New York: John Wiley. 715 pp., 1951 (Second Edition).

In this second edition new material has been added on marine bipolarity, coral reefs and intertidal zonation, to mention fields of particular interest to marine ecologists, as well as discussions of "rules" governing the distribution and structure of vertebrates, and the bibliographies have been brought up to date and recast in more extended form. This latter change is an especially welcome one, since a reference without title is often the stimulus to a wild goose chase through the literature. The book has been expanded from 597 to 715 pages, and the price raised to $9.50. (Joel W. Hedgpeth)

Hiatt, Robert W.
A directory to the marine laboratories of the United States and Canada: Contribution No. 4, Hawaii Marine Laboratory, pp. 1-70, 1950.

This bound mimeographed volume gives essential facts about 55 institutions - location, names of Director and staff, financial support, season of operation, functions, courses offered, available facilities for research, and expenses.

Hylander, Clarence
Sea and shore, pp. 242, Macmillan, 1950.

Hyman, Libbie H.
The invertebrates: the Acoelomate Belateria, Platyhelminthes and Rhynchocoela, vol. 2, pp. 550, McGraw-Hill, 1951.

Hyman, Libbie Henrietta
The invertebrates: Acanthocephala, Aschelminthes and Entoprocta, the pseudococlomati bilateria, vol. 3, pp. 572, McGraw-Hill, 1951.

Jespersen, Poul
Investigations on the occurrence and quantity of holoplankton animals in the Isefjord, 1940-1943: Meddel. Komm. Danmarks Fiskeri-og Havundersögelser Ser. Plankton, vol. 5, no. 3, pp. 1-18, Illus., 1949.

Johnson, J. Harlan
An introduction to the study of organic limestones. (Revised edition): Colorado School of Mines Quarterly, vol. 46, no. 2, pp. 1-185, 1 text fig., 104 pls., 1951.

In the 185 pages and 104 plates of this book Dr. Johnson has compressed into small space much ecological information about the plants and animals that contribute to the making of calcareous rocks. Many of the examples are from the author's studies of calcareous algae in the complex communities of organisms that are called coral reefs in the Pacific Islands. The numerous illustrations, plus the descriptions,

arranged according to the classification of animal phyla, with a chapter on the algae, should prove very useful to the student in getting oriented before making detailed identifications. (Roland W. Brown)

Jones, N. S.
Marine bottom communities: Biol. Reviews, vol. 25, no. 3, pp. 283-313. 1950.

Review, with bibliography, of literature on bottom communities, especially in North Atlantic and North Sea areas. A classification, modified from Sheflord, is proposed.

Jones, N. S.
The bottom fauna off the south of the Isle of Man: Jour. Anim. Ecology, vol. 20, no. 1, pp. 132-144, 1 fig., 1951.

Four types of bottom deposit were distinguished within a radius of 15 miles from Port St. Mary: (a) coarse sands, gravels and shell, including stony ground, (b) fine sand, (c) muddy sand, and (d) mud. Their limits are fixed by wave action and the strength of currents. Each type of deposit carries a distinct faunal assemblage which may be considered as a main community. The fauna is not evenly distributed within each community area, but further subdivision was not considered justifiable. The communities are described and the characteristic animals listed. The biomass, as estimated from quantitative samples, shows a poor production as compared with some other areas. In the Isle of Man area there is only a slight preponderance of southern as against northern forms in the fauna. (Joel W. Hedgpeth)

Korringa, P.
Experiments and observations on swarming, pelagic life and setting in the European flat oyster, Ostrea edulis Ls.: Arch Nederland. Zool., vol. 5, nos. 1-2, pp. 1-249, 24 figs., 1940.

Kuznetzov, V. V.
Popoluiatsii nekotorigh massovigh vidov morskigh beslozvonochnigh vostochnogo Murmana: Zool. Zhurnal, vol. 26, no. 2, pp. 109-122, 1947. (Populations of some mass species of marine invertebrates of East Murman).

The character of the communities are determined initially by physical (abiotic) conditions, and a change in physical conditions rather than in predation interrupts the growth of the population. It is suggested that types occurring in masses possess to one degree or another the ability of passing from type of nutrition to another, and that it can be assumed that food is not an object in the struggle for life of such organisms. (From Engl. summary)

Ladd, H. S.; Tracey, J. I., Jr.; Wells, J. W.; and Emery, K. O.
Organic growth and sedimentation on an atoll: Jour. Geology, vol. 58, no. 4, pp. 410-425, 1950.

Ladd, H. S. and Tracey, J. I., Jr.
Coral Reefs in colour: Geog. Mag., vol. 23, no. 9, pp. 373-383, 1951.

Levet, Melvin N.
Summary of Russian papers on Upper Paleozoic reefs: Jour. Geology, vol. 58, no. 4, pp. 426-429, 1950.

Lowenstam, Heinz A.
Niagaran reefs of the Great Lakes area: Jour. Geology, vol. 58, no. 4, pp. 430-487, 1950.

MacNeil, F. Stearns
Planation of Recent reef flats on Okinawa: Bull. Geol. Soc. America, vol. 61, pp. 1307-1308. 1950.

Strong evidence is presented indicating that the present flats surrounding the island have been truncated by wave action and solution during very recent times -- that several feet of reef rock have been removed from flats that in some places exceed 1,000 feet in width. Blocks of an older reef limestone (Tertiary or early Pleistocene) weighing many tons are perched on pedastals 5 to 6 feet high at appreciable distances from shore. These masses of limestone have broken from shoreline cliffs and appear to have crept, slid or rolled over underlying clays until they came to rest on a reef flat that stood 5 or 6 feet higher than now. Since that time they have been isolated by erosion. Where such blocks are absent the wide reef flats are as bare as they are in most parts of the coral seas. The author tentatively assigns the reef surface represented by the tops of the pedestals to the period known as the "Climatic Optimum", believed by many to have been about 4,000 to 6,000 years ago. That similar planation may have taken place in other parts of the Coral Seas is mentioned as a possibility.

Mathews, William H.
Some aspects of reef paleontology and lithology in the Edwards formation of Texas: Texas Jour. Sci., no. 2, pp. 217-226, 1951.

Menard, Henry W., and Boucot, A. J.
Experiments on the movement of shells by water: Am. Jour. Sci., vol. 249, pp. 131-151, 1951.

Miner, Roy Waldo
Field book of seashore life: New York: G. P. Putman's, 888 pp., 24 color plates, 251 black and white.

A compact, concise field guide to Atlantic coast invertebrates from New England to Beaufort. The nomenclature in many groups is unfortunately archaic. (Joel W. Hedgpeth)

Moore, Hilary B.
The relation between the scattering layer and the Euphansiacea: Biol. Bull., vol. 99, no. 2, pp. 181-212, 1950.

Newell, Norman D.; Rigby, J. Keith; Whiteman, Arthur J.; and Bradley, John
Shoal-water geology and environments, eastern Andros Island, Bahamas: Bull. Amer. Mus. Nat. Hist., vol. 97, Art. 1, pp. 1-29, 5 figs., 8 pls., 1951.

An excellent account of the geology, ecology, and sedimentary environments of an Atlantic coral reef area; well documented with photographs and sketches.

Nikolsky, George
O biologicheskoi spetsifike faunisticheskich kompleksov i znachenii ee analiza dlia zoogeographii: Zool. Zhurnal, vol. 26, no. 3, pp. 221-231, 1947. (On biological peculiarities of faunistic complexes and their analysis for zoogeography).

Zoogeographical distribution into definite regions is a stage of study which belongs chiefly to the past; the unit of zoogeography should be the faunistic complex based on ecologic specificity. (From Engl. summary)

Panikkar, N. Kesava
Physiological aspects of adaptation to estuarine conditions: Proc. Indo-Pacific Fisheries Council, 1950 (III), pp. 168-175, 1951.

A summary of the literature, with reference to estuaries of south Asia.

Pearse, A. S.
The emigrations of animals from the sea: Dryden, N. Y.: The Sherwood Press, 210 pp., illus., 1950.

A revised edition of The Migrations of Animals from Sea to Land, with 43 pages of bibliography.

Pearse, A. S. and Williams, L. G.
The biota of the reefs off the Carolinas: Jour. Elisha Mitchell Sci. Soc., vol. 67, no. 1, pp. 133-161, 5 figs., 1951.

A list of the plants and animals dredged from 12-55' off the vermetid-serpulid reef formations of the Carolina coast. The biota is predominantly southern in its characteristics; 167 species are considered to be "south ranging" species; 18 are northern forms and 63 are eurythermal. (Joel W. Hedgpeth)

Pyefinch, K. A.
Notes on the ecology of ship-fouling organisms: Jour. Anim. Ecol., vol. 19, no. 1, pp. 29-35, 1950.

Remane, Adolf
Das Vordringen limnischer Tierarten in das Meeresgebiet der Nord- und Ostsee: Kieler Merresf., vol. 7, no. 2, pp. 5-23, 1950.

A general survey of the freshwater element in the waters of the Baltic and North seas. Very few such forms have invaded the pelagic; most of the invaders have settled in the littoral, instrand pools, interstitial water of sandy beaches, in Enteromorpha, etc. Most of this fauna is recruited from a few groups: Oligochaeta, rotifers, diptera

larvae, etc. Certain groups, limnic crustacea, mites, mollusca, mayflies and stone flies, are strongly halophobic. Euryhaline limnic animals are able to colonize highly saline areas successfully, and the biota of such supersaline areas has a high limnic element. (Joel W. Hedgpeth)

Rochford, D. J.
Hydrology of the estuarine environment: Proc. Indo-Pacific Fisheries Council, 1950 (III), pp. 157-168, 10 figs., 1951.

Description of certain Australian estuary systems, with a suggested general classification in terms of gradient, chlorinity, temperature and silt deposition. Estuaries are considered in terms of their relation to fresh water and tidal action, i.e., marine dominated gradient dominated, freshwater dominated, and atidal systems. (Joel W. Hedgpeth)

Santos-Pinto, Jaime dos
Um caso de "red water" motivado por abundancia anormal de Goniaulax poliedra Stein: Bol. Soc. Portuguesa Ciênc. Nat., vol. 17, no. 2, pp. 94-96, illus., 1949. [A case of red water caused by abnormal abundance of G. poliedra Stein].

Segerstrale, Sven G.
The brackish-water fauna of Finland: Oikos, vol. 1, no. 1, pp. 127-141, fig. 7, 1949.

General discussion of fauna of Gulf of Finland with selected bibliography. The fauna is poor in number of species, rich in individuals, and sizes of marine organisms are reduced in the lowered salinities. (Joel W. Hedgpeth)

Segerstrale, Sven G.
The recent increase in salinity off the coasts of Finland and its influence upon the fauna: Jour. du Conseil, vol. 17, no. 2, pp. 103-110, 2 figs., 1951.

In the last thirty years there has been a rise in annual mean salinities in the Baltic of from ½ to 3/4 o/oo. While not large, this increase is having a perceptible effect on the reproductive areas for the medusa Aurelia aurita, which has been spreading since the increase in salinity. Accompanying the increase in salinities, which favors spread of marine animals in the Baltic, is an amelioration of the climate permitting the northward extension of certain birds and mammals. (Joel W. Hedgpeth)

Seshappa, G.
Studies on the vertical distribution and general ecology of some of the common intertidal organisms of the Northumberland Coast: 210 pp., illus., Thesis, U. Durham, Eng., 1948.

Shepard, Francis P.
Sand and Gravel in deep-water deposits: World Oil, Jan. 1951.

Smith, F. G. Walton; Williams, Robert H.; and Davis, Charles C.
An ecological survey of the subtropical inshore waters adjacent to Miami: Ecology, vol. 31, no. 1, pp. 119-146, 1950.

Stephenson, T. A. and Stephenson, Anne
The universal features of zonation between tide-marks on rocky coasts: Jour. Ecol., vol. 37, no. 2, pp. 289-305, 1949.

Stephenson, T. A. and Stephenson, Anne
Life between tide-marks in North America: Jour. Ecol., vol. 38, no. 2, 354-402, 1950.

Stephenson, W.
Preliminary observations upon the release of phosphate from estuarine Mud: Proc. Indo-Pacific Fisheries Council 1950 (III): pp. 184-189, 1 fig., 1951.

Organisms present in estuarine muds caused marked and uncontrollable changes under laboratory conditions. The presence of animals sometimes increase absorption of phosphates, and at other times initiates evolution of phosphate. Superficial deposits from a polluted estuary can release large amounts of phosphate while subsurface layers may absorb or evolve it. When the supernatant water is de-oxygenated, large amounts of phosphate are given off, which may be partially due to catastrophic biological changes. (Joel W, Hedgpeth)

Tasch, Paul
Fauna and paleoecology of the upper Cambrian Warrior formation of central Pennsylvania (abstract): Bull. Geol. Soc. Amer., vol. 61, no. 12, pt. 2, p. 1508, 1950.

Termier, Henri & Genevieve
Les Herbiers Marins et la Signification des Faunes Pyriteuses: La Revue Scientifique, no. 3309, pp. 16-26, Jan.-Mar. 1951.

Thorson, Gunnar
Reproductive and larval ecology of marine bottom invertebrates: Biological Reviews, Cambridge Philosophical Society, vol. 25, no. 1, pp. 1-45, 6 text figs., January 1950.

Gunnar Thorson of the Zoological Museum of the University of Copenhagen has made this important investigation of the larval and reproductive ecology of the marine invertebrates, not as a quantitative or distributional study in the interest of the fisherman but in a search for the basic knowledge of the factors which enable forms to maintain their populations within a certain sea area. These are some of his findings.

In such a study, the most sensitive stage, the period of breeding and larval development is the most significant in the life cycle. The waste attending this period is critical and may determine whether the stock will survive. Those species producing a very large number of

eggs have a long and hazardous pelagic life; but if number of eggs is relatively small, the length of life in the plankton is much reduced or may be eliminated altogether. Large fluctuations in the invertebrate bottom communities indicate genera such as Abra, Cultellus and Corbula with a long pelagic life while populations which remain relatively constant from year to year such as some of the Nuculas have a very short pelagic development, or, in Macoma calcarea, none at all. Embryos with a non-pelagic development, may originate from large yolky eggs or from small ones supplemented by nurse eggs. Pelagic larvae include the licithotrophic, originating from large eggs spawned in small numbers and feeding on their own yolk content; and the planktotrophic, spawned in very large numbers and feeding on the phytoplankton. The first type of larvae is rare in the lamellibranchs and unknown in the gastropods. The planktotrophic larvae include prosobranchs, tectibranchs and lamellibranchs and are best fitted to be invaders and establish new populations. Over 70% of the marine invertebrates are planktotrophic in the larval stage. Starvation of larval life is probably indirect: poor food conditions cause slow growth, thereby prolonging the larval stage and giving the enemy a longer period in which to attack. Low temperatures, also, are unfavorable in that they hinder growth and metamorphosis and thus favor the enemy. Apparently, there is no great hazard attending the physiological revolution which occurs when larvae feeding on algae alone, change into carniverous bottom animals. The young pelagic larvae are photopositive and crowd near the surface while those about to metamorphose are photo-negative. If the substratum is not to their liking, the metamorphosis may be delayed to some extent. Currents from the open ocean may transport larvae from the continental shelf to the deep sea where pelagic development is nearly or totally suspended. In the arctic seas, pelagic life is almost absent but it increases southward and reaches a maximum on the tropic shelves. In order to survive in high arctic seas, a planktotrophic pelagic larva must complete its development from egg to metamorphosis within 1 to 1½ months at a temperature below 2° to 4°. Ninety-five percent of the species are unable to do so but any pelagic larval form that is able to develope under those severe conditions, has a good chance of survival.

An extensive bibliography completes the valuable paper. (Julia Gardner)

Tully, John P.

Oceanography and prediction of pulp mill pollution in Alberni Inlet: Fisheries Res. Bd. Canada Bull. 83, 169 pp., 62 figs., 1949.

Detailed analysis of the hydrography of a British Columbia fjord; conditions are estuarine, and rate of exchange of fresh and salt water is such that proposed pulp mill would cause intolerable pollution. Aside from its excellence as a contribution to estuarine hydrography, this seems to be the first attempt to deal with pollution before the fact in such a critical manner. (Joel W. Hedgpeth)

Urey, H. C.; Lowenstam, H. A.; Epstein, S.; and McKinney, C. R.
Measurement of Paleotemperatures of the Upper Cretaceous of England, Denmark, and the southeastern United States: Bull. Geol. Soc. America, vol. 62, no. 4, pp. 399-416, 1951.

Waddensymposium, Tijdschrift Koninklijk Nederlansch Aardrijkskundig Genootschap, pp. 1-148, May 1951.

A series of 15 papers dealing with the hydrographic, sedimentary and ecologic conditions of Netherlands tidal flats (Wadden).

Whitten, H. L.; Rosene, Hilda F.; Hedgpeth, J. W.
The Invertebrate Fauna of Texas Coast Jetties; A preliminary survey; with a systematic appendix by J. W. Hedgpeth: from Pub. Inst. of Marine Science, vol. 1, no. 2, pp. 53-87, 1950.

1. An ecological survey of the marine invertebrate fauna was conducted on the jetties of the Texas coast during the months of June and July in 1938, 1939, and 1940.

2. The jetties guard 5 passes to inland bays which are maintained as navigable waterways, but the actual rocky area is a sandy beach only 400 miles long.

3. The usual tidal range on the Texas coast is from 1½ to 2 feet.

4. The passes guarded by these jetties are subject to an annual salinity range of at least 20 parts per thousand (ca 15 to 35 0/00 from Port Aransas north) and an annual temperature variation from 9° to 30° C.

5. This study was confined primarily to the fauna of the intertidal community of the Texas jetties. This community, considering the coast as a whole, is composed principally of 3 species of barnacles, 1 limpet, 1 littorine, either Littorina irrorata or the smaller L. ziczac, or both with an occasional L. nebulosa, 1 mussel, a Thais, an anemone, the isopod, Ligyda, and a hermit crab.

6. Mytilus recurvus, Littorina irrorata and possibly Balanus eburneus more common on the northern jetties; Chthamalus, Siphonaria naufragum and Littorina ziczac on the southern. Change in salinity probably a more potent cause than change in temperature. (Julia Gardner)

Williams, O. B.
Marine microbiology: Texas Jour. Sci., no. 1, pp. 69-75, 1951.

Wilson, Douglas P.
Life of the Shore and Shallow Sea: London: Nicholson and Watson, 213 pp., 44 pls., 10 text figs, 1951.

The second edition of one of the finest of all the seashore books, freshened up by a change of photographs and brought up to date by a complete overhaul of the text. (Joel W. Hedgpeth)

Wilson, James Lee
Paleoecology: Texas Jour. Sci., vol. 3, no. 1, 58-65, 1951.

General lecture on the subject.

Woodring, W. P., and Bramlette, M. N.
Geology and Paleontology of Santa Maria District, California: U. S. Geol. Surv., Prof. Paper 222, pp. 1-185, 1950.

Zenkevich, L. A.
Fauna i biologischeskiia produktivnost' moriia. Tom. II. Moria SSSR. "Fauna and biological productivity of the seas, vol. 2, Seas of USSR.": Moscow: Soviet Science, 588 pp., 327 figs., 1947.

A general review of the marine fauna in relation to the fisheries, with summaries and reviews of the recent Russian literature on the subject, especially that concerning bottom populations. A large part of this literature is otherwise inaccessible to American workers; some of the journals are unobtainable. The book is profusely illustrated, with numerous tables as well as charts and diagrams so that it should be extremely valuable even to those who must decipher each word with a dictionary. (Joel W. Hedgpeth)

Zernov, S. A.
Obshchaia hidrobiologiia. 2nd Ed.: Moscow-Leningrad: Acad. Sci. U.S.S.R., 587 pp., 216 figs., 1949.

This second edition of Zernov's "General hydrobiology" has been expanded and brought up to date, reviewing the literature since the first edition of 1934. The book still remains the only general text to discuss both fresh water and marine biology as an integrated subject. (Joel W. Hedgpeth)

Zeuner, Frederick E.
Dating the past: an introduction to geochronology, 2nd Ed., 474 pp., 24 pls., Longmans, Green, New York, 1951.

PLANTS

Aleem, A. A.
Distribution and ecology of marine littoral diatoms. Consideration of the littoral diatom-flora with special reference to forms living in gelatinous tubes: Bot. Notiser, Lund, 1949, pp. 517-54, 1949.

Aleem, A. A.
Distribution and ecology of British marine littoral diatoms: Jour. Ecology, vol. 38, pp. 75-106, 1950.

Aleem, A. A.
The diatom community inhabiting the mud-flats at Whitstable: Keut. New Phytol., vol. 49, pp. 174-188, 1950.

Burrows, Elsie M., and Lodge, Sheila
Antecology and the species problem in Fucus: Jour. Marine Biol. Assoc., vol. 30, no. 1, pp. 161-176, 1951.

Dexter, Ralph W.
Restoration of the Zostera faciation at Cape Ann, Massachusetts: Ecology, vol. 31, no. 2, pp. 286-288, 1 fig., 1950.

When surveyed in 1949, eel grass had not yet returned to the region as a whole but had become reestablished in one small cove. The reconstituted community is described.

Dickinson, C. I. and Foote, V. I.
Marine algae from the Gold Coast: Kew Bull., no. 2, pp. 267-272, 1950.

Doty, Maxwell S., and Archer, Justine
An experimental test of the tide factor hypothesis: Amer. Jour. Bot., vol. 37, no. 6, pp. 458-464, 1950.

Intertidal algal spp. forming the substrata for a general study of theories of intertidal zonation were exposed to progressively longer intervals of immersion in warm sea water, or concd. sea water or to a formaldehyde soln. When the exposure-time-interval was doubled or trebled over that time at which only some injury took place, death occurred sufficiently frequently to indicate that the algae have a physiology that would lead them to be sharply restricted in vertical range by exposures such as provided by tide factors. The tide factors are considered to be primary factors controlling abrupt variations in secondary factors that in turn, have a physiological, or at times physical, vertical-range-limiting effect on intertidal organisms. (M. S. Doty)

Biological Abstracts, vol. 25, no. 2, February, 1951.

Ercegovic, Ante
Ekološke i sociološke studije o litofitskim cijanoficejama sa Jugoslavenske obale jadrana: "Rada" Jugosl. akad. snan. umjetn. Zagreb, vol. 244, pp. 129-220, 4 pls. 10 figs., 1932.

Études écologiques et sociologiques des cyanophycées lithophytes de la côté Youguslave de l'Adriatique: Bull. intern. Acad. Yugos. sci. arts (Sci. math. nat.), vol. 26, pp. 33-56, 1932.

Wellengang und lithophytenzone an der Ostadriatischen Küste: Acta Adriatica, no. 3, 20 pp., 1 pl., 1 fig., 1934.

Although the second title here appeared in a separate journal, it is actually a condensation of the Jugoslav text, with cross references to the figures. The third title reviews the same material. The author's thesis is that the zonation of algae observed in the upper Adriatic is primarily the result of wave action. The various associations of blue green algae are described and analysed in some detail. (Joel W. Hedgpeth)

Fauré-Fremiet, E.
The tidal rhythm of the diatom Hantschia amphioxys: Biol. Bull., vol. 100, no. 3, pp. 173-177, 1 fig., 1951.

Tidal rhythm, characterized by periodic inversion of phototropistic response, persists in this sand dwelling diatom some days after removal to the laboratory. Production of organic substance contributes to stability of the sand layer of the beach and provides the necessary conditions for an interstitial microfauna. (Joel W. Hedgpeth)

Hustedt, F.
Die Diatomeenflora des Küstengebietes der Nordsee vom Dollart bis zur Elbemündung. I. Die Diatomeenflora in den Sedimenten der unteren Ems sowie auf den Watten in der Leybucht, des Memmert und bei der Insel Juist.: Abh. Nat. Ver. Bremen, vol. XXXI, pp. 572-677, 1939.

Hustedt, F., and Aleem, A. A.
Littoral diatoms from the Salstone, near Plymouth: Jour. Marine Biol. Assoc. United Kingdom, vol. XXX, pp. 177-196, 1951.

Johnson, J. Harlan, and Ferris, Bernard J.
Tertiary and Pleistocene coralline algae from Lau, Fiji: Bishop Museum, Bull. 201, pp. 1-27, 1950.

Kornaś, J., and Medwecka-Kornaś, A.
Associations végétales sous-marines dans le Golfe de Gdańsk (Baltique polonaise): Bull. Acad. Polon. Cl. Math. Nat. Sér B I., pp. 71-88, 1948; Also in: Vegetatio, vol. 2, nos. 2-3, pp. 120-128, 1949. (Plant associations of the sea bottom in the Bay of Gdańsk-Polish Baltic).

The marine vegetation of the Bay of Gdańsk was investigated by appln. of the methods of the phytosociological school Zürich-Montpellier. A diving helmet was used for the 1st time for such a purpose. Therefore the phytosociological lists may be assumed to be as accurate as those of terrestrial vegetations. 5 associations (in the sense of Braun-Blanquet) were distinguished and described: Fuceto-Furcellarietum at the depths of 2.5-4 m.; Chareto-Tolypelletum at depths of 2-3 m.; Cladophora glaucescens community at depths of 60 cm.; Enteromorpha linza-Spirulina subsalsa community in the harbors at depths up to 5 m.; Enteromorphetum compressae close under the water level in the harbors. (A. and J. Kornaś)

Biological Abstracts, vol. 25, no. 4, April, 1951.

Kosanke, R. M.
Pennsylvanian plant microfossils and paleoecology (abstract): Bull. Geol. Soc. Amer., vol. 61, no. 12, pt. 2, p. 1478, 1950.

Pillsbury, R. W.
Natural anchoring of the red algae, Gracilaria confervoides (L.) Grev. on unstable bottom by association with an annelid worm: Canadian Jour. Res. Sect. C. Bot. Sci., vol. 28, no. 5, pp. 471-476, 1950.

Smith, Gilbert M. (Editor) and others
Manual of Phycology: An introduction to the algae and their biology, pp. xi, 375, Waltham, Mass.: The Chronica Botanica Co.; New York: Stechert Hafner Inc. $7.50. 1951.

In this symposium volume, which summarizes the classification and knowledge of the biology of the algae up to 1948, are several chapters of particular interest to marine ecologists and paleoecologists. Since the algae are construed in the broadest sense, there is also a chapter on the dinoflagellates (Pyrrophyts, by H. W. Graham), which suffers, however, from the 1948 closing date for the bibliography. One of the shortest chapters is that by J. Harlan Johnson on fossil algae. This is a reflection of the incomplete state of paleoalgalogical studies (only 33 titles are listed) but is nevertheless a useful summary. The chapter "Ecology of Marine Algae" by Jean Feldmann is an important contribution. In this chapter, supported by 96 references, algal floras are divided into formations, then subdivided into facies (the nature of the substratum), modes (salinity and exposure), associations (predominant algal species), which often occur in girdles (a term advanced by Fritsch to replace "zone"). The intertidal is divided into belts (rather than zones), as follows: supralittoral, littoral, upper and lower infralittoral. The factors influencing the distribution of marine algae are summarized, but the incomplete nature of our knowledge of marine algal ecology is stressed. The author considers that the establishment of a uniform terminology is a necessary adjunct to adequate comparative studies of algal ecology on the various coasts. In a chapter titled "Plankton algae and their biological significance" Bostwick H. Ketchum presents an excellent condensation of our knowledge of the dynamics of phytoplankton in the seas, with a bibliography of 122 titles. Many other chapters include information of interest to ecologists, especially students of reef formation, symbiosis, and physiology (this chapter, by L. R. Blinks, includes 8 pages of bibliography). The book as a whole is an indispensable guide for students of algae, and a useful key to the literature. (Joel W. Hedgpeth)

Waern, Mats
Remarks on Swedish Lithoderma: Svensk Bot. Tidskr., vol. 43, nos. 2-3, pp. 633-670, illus., 1949.

ZoBell, Claude E.
To what depth are bacteria active in marine bottom deposits; 4th Internatl. Cong. for Microbiology, Copenhagen, p. 452, 1947.

PROTOZOANS

Graham, Joseph J.
Foraminifera of the type Meganos formation (Eocene) of central California (abstract): Bull. Geol. Soc. Amer., vol. 61, no. 12, pt. 2, p. 1538, 1950.

Gunter, Gordon
Mass mortality and dinoflagellate blooms in the Gulf of Mexico: Science, vol. 113, pp. 250-251, 1951.

Khan, M. H.
Note on the depth and temperature of the Gault Sea as indicated by Foraminifera: Geol. Mag., vol. LXXXVII, no. 3, pp. 175-180, 1950.

LeRoy, L. W.
Additional comments on the stratigraphic distribution of Orbulina universa D'Orbigny (abstract): Bull. Geol. Soc. Amer., vol. 61, no. 12, pt. 2, p. 1555, 1950.

Mandra, York T.
Studies on fossil silicoflagellates (abstract): Bull. Geol. Soc. Amer., vol. 61, no. 12, pt. 2, p. 1539, 1950.

Phleger, Fred B. and Walton, William R.
Ecology of Marsh Bay Foraminifera, Barnstable, Mass.: Amer. Jour. Sci., vol. 248, no. 4, pp. 274-294, 1950.

Rau, Weldon W.
Tertiary Foraminifera from the Willapa River valley of southwest Washington (abstract): Bull. Geol. Soc. Amer., vol. 61, no. 12, pt. 2, p. 1540, 1950.

Said, Rushdi
The distribution of Foraminifera in the Northern Red Sea: Contrib. from the Cushman Foundation for Foram. Res., vol. 1, pts. 1 and 2, pp. 9-29, 1950.

A new method of representing populations is used, making possible comparisons between distant regions. Instead of percentage of total population, actual numbers of specimens per gram dry weight of sediment were counted and represented graphically for the more abundant species in 50 bottom samples. Four overlapping depth zones of benthonic populations were observed, apparently not dependent upon temperature regulation.

A gross relationship between total number of benthonic Foraminifera and nitrogen percentage was found. Topographic position from which the sample was procured and the median diameter of the sediment are important factors determining the concentration of Foraminifera.

The depth ranges and abundance of several significant species are represented in bathymetric distribution curves.

Affinities of the present day fauna suggest that Pleistocene climatic fluctuations altered currents so as to allow free exchange of benthonic Foraminifera between the Red Sea and adjacent seas. The present regime of currents results in isolation of this area. (M. Ruth Todd)

Said, Rushdi
Nummulites gizehensis as a possible indicator of Eocene climate: Contrib. from the Cushman Foundation for Foram. Res., vol. 1, pts. 1 and 2, pp. 30-31, 1950.

The observed tightening of the spire in Nummulites gizehensis, together with the assumption that the life cycle of the species was about one year, indicates a seasonal fluctuation in food supply. As tropical regions have two maxima per year in their organic production, this evidence indicates a temperate climate in the Eocene. No consideration is given the possibility that tightening of the spire may be a gerontic development. (M. Ruth Todd)

Takayanagi, Yokichi
Pliocene smaller Foraminifera from western Sendai: Short Papers from the Inst. Geol. & Pal., Tohoku Univ., no. 2, pp. 22-28, 1950.

Young, Keith
Foraminifera and stratigraphy of the Frontier formation (Upper Cretaceous), southern Montana: Jour. Paleo., vol. 25, no. 1, pp. 35-68, 1951.

SPONGES

DeLaubenfels, M. W.
Sponges of the western Bahamas: Amer. Mus. Novitates, no. 1431, pp. 1-25, illus., 1949.

COELENTERATES

Boschma, H.
The species problem in Millepora: Zool. Verhandl. Mus. Leyden, vol. 1, pp. 1-115, 15 pls., illus., 1948.

Boschma, H.
Notes on the coral reefs near Suva in the Fiji Islands: Proc. K. Nederland. Akad. Wetenschap. Amsterdam, vol. 53, no. 3, pp. 294-298, illus., 1950.

On the reef flats the commonest coral is Acropora millepora. There are also numerous colonies of an incrusting Montipora that appears to live under more or less adverse conditions. The reef, especially the southern part, further contains a variety of spp. belonging to other genera of Madreporaria, the greater part in rather poor condition. Hydrocorallia of the genus Millepora are fairly numerous on the seaward border of the reef. M. tenera apparently finds here excellent conditions for luxurious development, whereas M. platyphylla remains stunted and only exceptionally rises above the incrusting stage. (H. Boschma)

Biological Abstracts, vol. 25, no. 6, June, 1951.

Nyhom, Karl-Georg
On the development and dispersal of Athenaria actinia with special reference to Halcampa duodecicirrata, M. Sars: Zool. Bidr. Uppsala 28, pp. 465-506, 3 pls., 20 figs., 1949.

The larvae of Halcampa are non-motile, and settle in the immediate neighborhood of the parent. The only period of dispersal is that between emergence of the egg and the formation of a gelatinous fertilization membrane. The relationship between this type of reproduction and the infection of medusae by planula stages of a related anemone are discussed. (Joel W. Hedgpeth)

Deevey, Edward S., Jr.
Hydroids from Louisiana and Texas, with remarks on the Pleistocene biogeography of the western Gulf of Mexico: Ecology, vol. 31, no. 3, pp. 334-367, 11 figs., 1950.

Finds, out of 39 species of hydroids, six or seven which have a boreal disjunct pattern, i.e., are northern species which skip southern Florida. A lowering of the average annual isothern at Key West by 5° C is postulated for the Pleistocene to account for the occurrence of these "glacial relicts." Submergence of Florida is not considered. (Joel W. Hedgpeth)

Umbgrove, J. H. F.
Corals from the Putjangan beds (Lower Pleistocene) of Java: Jour. Paleo., vol. 24, no. 6, pp. 637-651, 1950.

VERMES

Correa, Diva Diniz
Ecological study of Brazilian Ototyphlonemertes: Comm. Zool. Mus. Hist. Nat. Montevideo, vol. 3, no. 55, 7 pp., 1 pl., 1949.

Observations on the habits of a nemertean living in the upper layers of a sandy beach.

McConnaughey, B. H., and Fox, D. L.
The anatomy and biology of the marine polychaete Thoracophelia mucronata (Treadwell) Opheliidae: Univ. California Publ. Zool., vol. 47, no. 12, pp. 319-340, illus., 1949.

ECHINODERMS

Child, C. M.
Differential modification of sand dollar development in relation to temperature: Physiol. Zool., vol. 23, no. 2, pp. 140-168, illus., 1950.

Krau, Luiza
Observacões sobre os equinodermas da Baia de Guanabara: Mem. Inst. Oswaldo Cruz, vol. 48, pp. 357-362, 1950.

MOLLUSKS

Abbott, R. Tucker

New deep-water olivellas from Florida, with notes on the O. jaspidea-nivea complex: Nautilus, vol. 64, no. 4, pp. 110-116, 1951.

Allan, Joyce

Australian Shells, with related animals living in the sea in fresh water and on the land: pp. XIX + 470, 12 colored plates, 32 black and white plates, 112 text figs., Georgian House, Melbourne, 1950. 60 shillings.

As a popular book, Australian Shells, will be welcomed by those interested in mollusks found not only in Australia but also the vast Indo-Pacific region. Three quarters of the book is devoted to the marine mollusks, the remainder to land and fresh-water shells.

It is a prodigious undertaking of over 250,000 words, and its appeal mainly lies in the interesting and accurate notes on the habits and distribution of many of the species. Miss Allan is not only a professional malacologist but a superb water-color artist, and her dozen color plates are highly satisfactory.

As an identification tool the book falls far short of its intended purpose. Probably not more than 10 percent of the 1000 species illustrated in line drawings are recognizable. This is also true of the majority of the 32 black and white plates. The publisher also failed to number the plates, an inconvenience which may be remedied by the reader only by adding numbers to his own copy.

In America, at least, amateurs as well as professionals desire to know the authorship of each species. This is especially important in the field of mollusks where so many homonyms exist. It is little short of criminal that Miss Allan has omitted every author's name, and states that the "more serious inquirer can obtain the information ... from a museum." She is to be commended, however, for her use of popular names, and if future authors of popular Pacific books will follow her system, there may be more stability among the popular names than among the ever-changing scientific ones.

One of the chief draw-backs of the book, especially to the serious amateur, is the Iredalian system of classification in which polytypic species are considered genera, and in which local races are looked upon as full species. One would believe that a species' presence in Australia is the sole justification of a new name. For example, the author follows Iredale's use of Tridacna derasa Roding for the Giant Clam, T. gigas. In contrast, although T. gloriosa Lamark is generally considered a synonym of T. noae Roding, the former is retained apparently because it comes from Australia.

It certainly would have been wiser to have left the many, poorly understood subgenera of Cypraea and Conus as such, and not raised them haphazardly to generic standing. Undoubtedly there are several good

genera in the old genus Cypraea, such as Umbilia and Erosaria, but the use of such genera asGratiadusta, Nivigena, Talostolida and Melicerona, to mention only a few, is as confusing to the professional as it must be to the amateur. Allan's treatment of the cones is a poor compromise between the Iredalian philosophy of monotypic genera and the more conservative view of this complex group taken by most malacologists.

Miss Allan has done an excellent job in discussing the economic, medical and ethnological aspects of mollusks, and her introductory chapters, including collecting methods, are worth reading. The book has a good binding, good format and print, poor paper and a high price. (R. Tucker Abbott)

Amengual-Ferragut, Jose

Ensayo de sistemática biocenótica aplicada al estudio de los yacimientos de moluscos, con un estudio inicial de los yacimientos de la ría de Noya: Bol. Inst. Español Oceanogr., vol. 20, pp. 1-70, 1949. (Attempt to apply biocenotic systematics to the study of mollusk beds, with an initial study of the beds of the Noya estuary).

Beaven, G. Francis

Effect of Susquehanna River stream flow on Chesapeake Bay salinities and history of past oyster mortalities on upper bay bars: Maryland Dept. Res. and Educ. Contrib., vol. 68, pp. 1-11, maps, 1946.

Boettger, Caesar R.

Ein Beitrag zur Frage des Ertragens von Brackwasser durch Molluskenpopulationen: Hydrobiologia, vol. 2, no. 4, pp. 360-379, 14 figs., 1950.

Description of molluscan populations of brackish sloughs and ponds in vicinity of Insel Rugen with data on size ranges of populations indicating smaller sized individuals in lower salinities. (Joel W. Hedgpeth)

Carriker, M. R.

Ecological observations of the distribution of oyster larvae in New Jersey estuaries: Ecol. Monogr., vol. 21, no. 1, pp. 19-38, 5 figs., 1951.

Older larvae of Crassostrea virginica migrate vertically in relation to tidal flow, rising on the flood and sinking toward bottom on the ebb, thus taking advantage of the tidal cycle to migrate toward the headwaters of estuaries. Active migration also occurs, thus enabling oyster larvae to travel against the gradient well beyond the distance made possible by tidal conveyance alone. (Joel W. Hedgpeth)

Chavan, A.

Remarques sur la signification climatique des Mollusques marins fossiles: Bull. de la Soc. Géol. de France, Fascicule 7-8-9, Feuilles 32 à 44 Planches XVI-XXIV, 49 figures, 2 tableaux dans le texte, 1949.

In Astarte, sometimes cited as an example of changing climatic conditions, some genera are boreal, others tropical. The type of Astarte, A. sulcata, is not a boreal species but is known from the Canaries. Isocrassina, of which A. castanea is the type, is a temperate group. Ashtarotha, type A. undulata Say, is not a strictly boreal species, but rather temperate or north temperate. In Venericardia, only the subgenus Cyclocardia is truly boreal while Venericardia, (Cardites) is a southern form. (Julia Gardner)

Cox, L. R.
Neogene Mollusca from the Dent Peninsula, British North Borneo: Schweiz. Palaeontol. Abhandl., vol. 66, no. 2, pp. 1-70, illus., 1948.

Darteville, Edmond
La cote et l'estuaire du Congo: Mem. Inst. Roy. Col. Belge (Sci. nat. et Med.), vol. 19, no. 2, 58 pp., 8 figs., 1950.

General description of estuary of Congo, with special reference to distribution of mollusca.

Fitch, John E.
The Pismo clam: California Fish and Game, vol. 36, no. 3, pp. 285-312, illus., 1950.

Fleming, C. A.
The molluscan fauna of the fiords of western Southland: New Zealand Jour. Sci. and Tech., vol. 5, pp. 20-51, 1950.

Fleming, C. A.
The molluscan fauna of the Pahi Grunsands, North Auckland: Trans. Royal Soc. New Zealand, vol. 78, pts. 2-3, pp. 236-250, 1950.

Gunter, Gordon
The species of oysters of the Gulf, Caribbean and West Indian Region: Bull. Mar. Sci. of Gulf and Caribbean, vol. 1, no. 1, pp. 40-45, 1951.

Gunter, Gordon
The West Indian tree oyster on the Louisiana coast, with notes on growth of the three Gulf coast oysters: Science, vol. 113, pp. 516-517, 1951.

Crassostrea virginica, Ostrea equestria and Ostrea frons found in the same locality but flourishing at different depths on structures associated with offshore drilling platforms.

Ingle, Robert M.
Summer growth of the American oyster: Science, vol. 112, pp. 338-339, 1950.

Isham, Lawrence B.; Smith, F. G. Walton; and Springer, Victor.
Marine borer attack in relation to conditions of illumination: Bull. Mar. Sci. Gulf and Carib., vol. 1, no. 1, pp. 46-63, 3 figs., 1951.

Wooden panels suspended in sea water and subjected to varying intensities of illumination show a maxium amount of teredid attack when subjected to 166 foot-candles. At higher and lower intensities of illumination the number of borings decrease. Limnoria burrows are most numerous at low intensity and decrease in number with increasing intensity of light. (from summary)

Kerswill, C. J.
Effects of water circulation on the growth of quahaugs and oysters: Jour. Fish. Res. Bd. Canada, vol. 7, no. 9, pp. 545-551, 1949.

Loosanoff, Victor L., and Davis, Harry C.
Conditioning V. mercenaria for spawning in winter and breeding its larvae in the laboratory: Biol. Bull., vol. 98, no. 1, pp. 60-65, 1950.

Clams normally spawning in summer can be induced to spawn in winter in laboratory after acclimation by decreasing or raising the temperature above the conditioning level. (Joel W. Hedgpeth)

Loosanoff, V. L.; Miller, W. S.; and Smith, P. B.
Growth and Setting of Larvae of Venus Mercenaria in Relation to Temperature: Journal of Marine Research, vol. X, no. 1, pp. 59-81, 9 fig., 3 tables, 1951.

Menzel, R. Winston
Early sexual development and growth of the American oyster in Louisiana waters: Science, vol. 113, pp. 719-721, 1951.

Sexual maturity occurred in oysters as young as 3 weeks in Louisiana waters, and on the assumption that a 4-week oyster will spawn, 4 generations a year are possible in a spawning season lasting 200 days. A faster rate of living for oysters in Louisiana as compared with more northern regions is indicated. (Joel W. Hedgpeth)

Nicol, David
Recent species of the lucinoid pelecypod Fimbria: Jour. Wash. Acad. Sci., vol. 40, no. 3, pp. 82-87, 1950.

Nicol, David
Recent species of the prionodont pelecypod Cucullaea: Jour. Wash. Acad. Sci., vol. 40, no. 10, pp. 338-343, 1950.

Nicol, David
Recent species of the veneroid pelecypod Arctica: Jour. Wash. Acad. Sci., vol. 41, no. 3, pp. 102-106, 1951.

Nicol, David
Recent species of the cyrenoid pelecypod Glossus: Jour. Wash. Acad. Sci., vol. 41, no. 4, pp. 142-146, 1951.

Shotwell, J. Arnold
The vertical zonation of Acmaea, the limpet: Ecology, vol. 31, no. 4, pp. 647-649, 3 figs., 1950.

Finds that upper limit of ranges of certain species on the Oregon coast correspond with critical tide levels at which extremes of dessication occur. The distribution of limpets may be governed by the distribution of the food supply (algae) but both may be limited by the same factor, the maximum time of uninterrupted exposure to air during the course of a year. (Joel W. Hedgpeth)

Shotwell, J. Arnold
Distribution of volume and relative linear measurement changes in Acmaea, the limpet: Ecol., vol. 31, no. 1, pp. 51-61, 1950.

Spärck, R.
On the distribution of the slipper-limpet (Crepidula fornicata) in Danish waters: Report Danish Biol. Sta., vol. 52, pp. 47-50, 1950.

ARTHROPODS

Corrivault, G. Wilfrid, and Tremblay, J. L.
Contribution a la biologie du homard (Homarus americanus Milne-Edwards) dans la Baie-des-Chaleurs et le golfe Saint Laurent: Contributions Sta. Biol. St. Laurent, vol. 19, 222 pp., 39 figs., 1948.

A comprehensive discussion of the systematic position, migrations, population growth, moulting physiology and sexual cycle of the lobster in the area.

Crisp, D. J.
Breeding and distribution of Chthamalus stillatus: Nature, vol. 166, no. 4216, pp. 311-312, 1950.

Doochin, Herman D.
The morphology of Balanus improvisus Darwin and Balanus amphitrite niveus Darwin during initial attachment and metamorphosis: Bull. Mar. Sci. Gulf and Carib., vol. 1, no. 1, pp. 15-39, 7 figs., 1941.

Haas, Fritz
Hermit crabs in fossil snail shells in Bermuda: Ecology, vol. 31, no. 1, p. 152, 1950.

Hedgpeth, Joel W.
Pycnogonids from Dillon Beach and vicinity, California, with descriptions of two new species: Wasmann Jour. Biol., vol. 9, pt. 1, pp. 105-117, 3 pls., 1951.

Incl. general description of area, and notice of a pycnogonid living in interstices of coarse sand.

Kesling, Robert V.
The morphology of ostracode molt stages: Ill. Biol. Monogr. 21, nos. 1-3, viii, 324 pp., 96 pls., 1951.

Knight-Jones, E. W., and Stevenson, J. P.
Gregariousness during settlement in the barnacle Elminius modestus Darwin: Jour. Marine Biol. Assoc. United Kingdom, vol. 29, no. 2, pp. 281-297, 1950.

Korringa, P.
Zeepokken en Getijstroom: Leverde Natuur, vol. 51, no. 11, pp. 156-157, 1948. (Barnacles and tidal currents).

Margalef, R.
Sobre la ecologia de las larvas del mosquito Aedes mariae: P. Inst. Biol. Apl. Barcelona, vol. 6, pp. 83-102, 3 figs., 1949.

Larvae occur in rock pools along shore. Daily thermal range is from 4-13° C, chlorinity is from 3.03 to 90.35, pH from 8.-8.4. Larvae of Aedes mariae endure from practically fresh water to water with a salinity 4 times that of sea water, respires normally under wave movement of water, feeds on the flagellates and debris of organic sediment. Oxygen consumption is near 1500-2000 ml O_2/Kg/hour. Neither predators nor salinity seem to be factors limiting the occurrence in the sea; wave action probably hinders oviposition, and the food requirements may not be met in the sea. "Selection has fixed likely an appropriate behavior of the egg deposing female, that may be attracted by the tranquille, salty and eutrophic pools."
(Joel W. Hedgpeth)

Ross, Reuben James
Stratigraphy of the Garden City formation in northeastern Utah, and its trilobite fauna: Peabody Mus. Nat. Hist., Yale Univ., Bull. 6, pp. 1-161, 1951.

Sohn, I. G.
Comparison of etched silicified ostracodes from limestone with calcareous forms from subjacent shale (abstract): Bull. Geol. Soc. Amer., vol. 61, no. 12, pt. 2, p. 1504, 1950.

Sohn, I. G.
Check list of salinity tolerance of post-Paleozoic fossil Ostracoda: Jour. Wash. Acad. Sci., vol. 41, no. 2, pp. 64-66, 1951.

Stephenson, K.
Two (sub)tropical crustaceans found north of Thule: Meddl. Gronl., vol. 150, no. 6, pp. 97-102, figs. 33-35, 1950.

Discusses the occurrence in western Greenland of two species whose established range is from southeastern U. S. coast and the American tropics.

Williams, G.
Distribution of Chthamalus stellatus on the shores of northeast Ireland: Nature, vol. 166, no. 4216, p. 311, 1950.

VERTEBRATES

Fleming, C. A.
Sea lions as geological agents: Jour. Sed. Petrology, vol. 21, no. 1, pp. 22-25, 1951.

Gudger, E. W.
Fishes that live as inquilines (lodgers) in sponges: Zool. (New York), vol. 35, no. 2, pp. 121-126, 1950.

Gunter, Gordon
Correlation between temperature of water and size of marine fishes on the Atlantic and Gulf Coasts of the United States: Copeia, pp. 298-304, 1950.

Gunter, Gordon
Distribution and abundance of fishes on the Aransas National Wildlife Refuge, with life history notes: Pub. Inst. Mar. Sci., vol. 1, no. 2, pp. 89-101, 1950.

Stations on the bay shore, fresh water ponds and salt flats were set up. The salt flat ponds undergo extreme annual and daily variations of temperature and seasonal variations in salinity. Salinities of the bay and salt flats averaged 12.2 and 18.3 parts per thousand, respectively. Rainfall was exceptionally high during the period of study. 29 species were taken on the bay shore, 17 on the flats, and 4 in an isolated fresh water pond. Cyprinodonts made up 74.9% of the total, comprising 28.5% of the bay catch, 67% from the salt flats and 79.3% from fresh water ponds. In the harsh marginal environment the cyprinodonts were dominant. (Author's abstract)

Myers, George S.
Salt-tolerance of fresh water fish groups in relation to zoogeographical problems: Bijdr. Dierk., vol. 28, pp. 315-322, 1949.

A review of the literature and listing of various families and genera of fish according to their ability to tolerate fresh water.

Wilson, John Andrew
A platysomid from the Double Mountain group of Texas: Jour. Paleo., vol. 24, no. 3, pp. 386-389, 1950.

PROBLEMATICAL FOSSILS

Yabe, Hisakatsu
Problematical fossils on the stratification plane of some older rocks from Japan and Manchuria: Proc. Japan Acad., vol. 25, no. 3, pp. 116-121, 1949.

THE CLASSIFICATION OF ESTUARINE AND BRACKISH WATERS AND THE HYDROGRAPHIC CLIMATE

by

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The hydrography and general ecological characteristics of those waters which are neither fresh nor marine, including bays, estuaries, brackish lagoons and mesohaline seas, are the subjects of an extensive and rapidly growing literature. Interest in the problems of brackish and estuarine waters has been a comparatively recent development of North America, although there have been many studies of such specific problems as oyster and crab biology, marine borers, and pollution of coastal waters which are, inter alia, problems concerned with estuaries and brackish waters. A large part of this literature has been assembled by Carriker (1950) as an adjunct to a course in estuarine ecology at Rutgers University. The recent establishment of the Chesapeake Bay Institute is a promising beginning towards an integrated analysis of our largest estuarine area (see Report No. 10, Committee on Treatise on Marine Ecology and Paleoecology, p. 3, 1950). The increasing magnitude of sewage and waste disposal problems has stimulated research in the physical dynamics of estuaries, both in the United States and Canada. The work by Tully (1949) on Alberni Inlet in British Columbia and the Colloquium on the Flushing of Estuaries held at Massachusetts Institute of Technology, September 7-8, 1950 (Stommel, 1950) are recent contributions to this phase of estuarine studies. The Indo-Pacific Fisheries Council, meeting at Cronulla, New South Wales, on April 17-28, 1950, devoted one of its technical sessions to a symposium on estuaries, especially as related to fisheries. In a paper for this symposium, Rochford (1951) presented a general scheme of classification for Australian estuaries. The famous "chlorinity spectrum" classification of Redeke (1922), based on the brackish waters of the Netherlands has been most recently reviewed by Dahl (1948) with reference to conditions in the lower Baltic. The present paper refers chiefly to specific environments within estuaries, the broader problem of the classification of the complex of environments in different estuaries will be treated elsewhere.

Although seldom precisely defined, the terms "brackish" and "estuarine" are clearly separable by usage. While "brackish" itself may be a vague term which has been applied to water which is not quite fresh as well as to highly concentrated brine, it carries with it a connotation of relatively stable conditions, or any rate a seasonal stability which is not included in the meaning of "estuarine." Estuarine waters are tidal waters (from L., aestus, the tide), and estuaries are river mouths. Thus there is in an estuary a daily regime of fluctuation as well as a seasonal one. The problems of estuaries are complex, from the viewpoint of both the hydrographer and the biologist, whether he be field ecologist, laboratory physiologist or systematist. These complexities have been concisely summarized in a diagram by Rochford (Figure 1).

1. The Classification of Brackish Waters

The widely used brackish water spectrum scheme of European workers is based on the floral and faunal characteristics of the waters rather than upon their hydrographic properties, although chlorinity is the secondary base for the classification. Since the biota is in effect a resultant of prevailing conditions, this scheme does provide a rough key to the hydrographic conditions. As originally proposed by Redeke (1922), this classification was related to chlorinity rather than to the total salinity, since the salinity determinations are derived from chlorinity content according to Knudsen's formula, and because the proportions of the ions are more variable in coastal and river waters than in the sea. For practical purposes, however, the salinities are now used. This scheme, as set up by Redeke and later amended by Välikangas (1933) is best presented in tabular form:

TABLE 1

Redeke (1922, 1933) Cl, o/oo		Välikangas (1933) S, o/oo
	Fresh water	
Less than 0.1	("Infrahaline")	Less than (0.2) 0.5
	Brackish water	
0.1 — 1.0	Oligohaline	(0.2)0.5 — (2.0)3.0
	Mesohaline:	
1.0 — 5.5	alpha (Redeke); meiomesohaline (Välikangas)	(2.0)3.0 — 8.0(10.0)
5.5 — 10.0	beta (Redeke); pleiomesohaline (Välikangas)	8.0(10.0) — 16.5
10.0 — 17.0	Polyhaline	16.5 — 30.0
	Marine water	
More than 17.0	("Ultrahaline")	More than 30.0

Remane (1934, 1940), proposed a somewhat different system, using such terms as "limnetic-brackish mixed area" and "marine brackish mixed area", and extending the limits for marine water down to about 16.5 o/oo S. This latter modification, as Dahl (1948) points out, seems to be based on Remane's experience with conditions in the Gulf of Kiel. In American waters a bay with an annual average salinity of 18.0 o/oo (e.g., Aransas Bay, Texas), is certainly not "marine" in faunal composition.

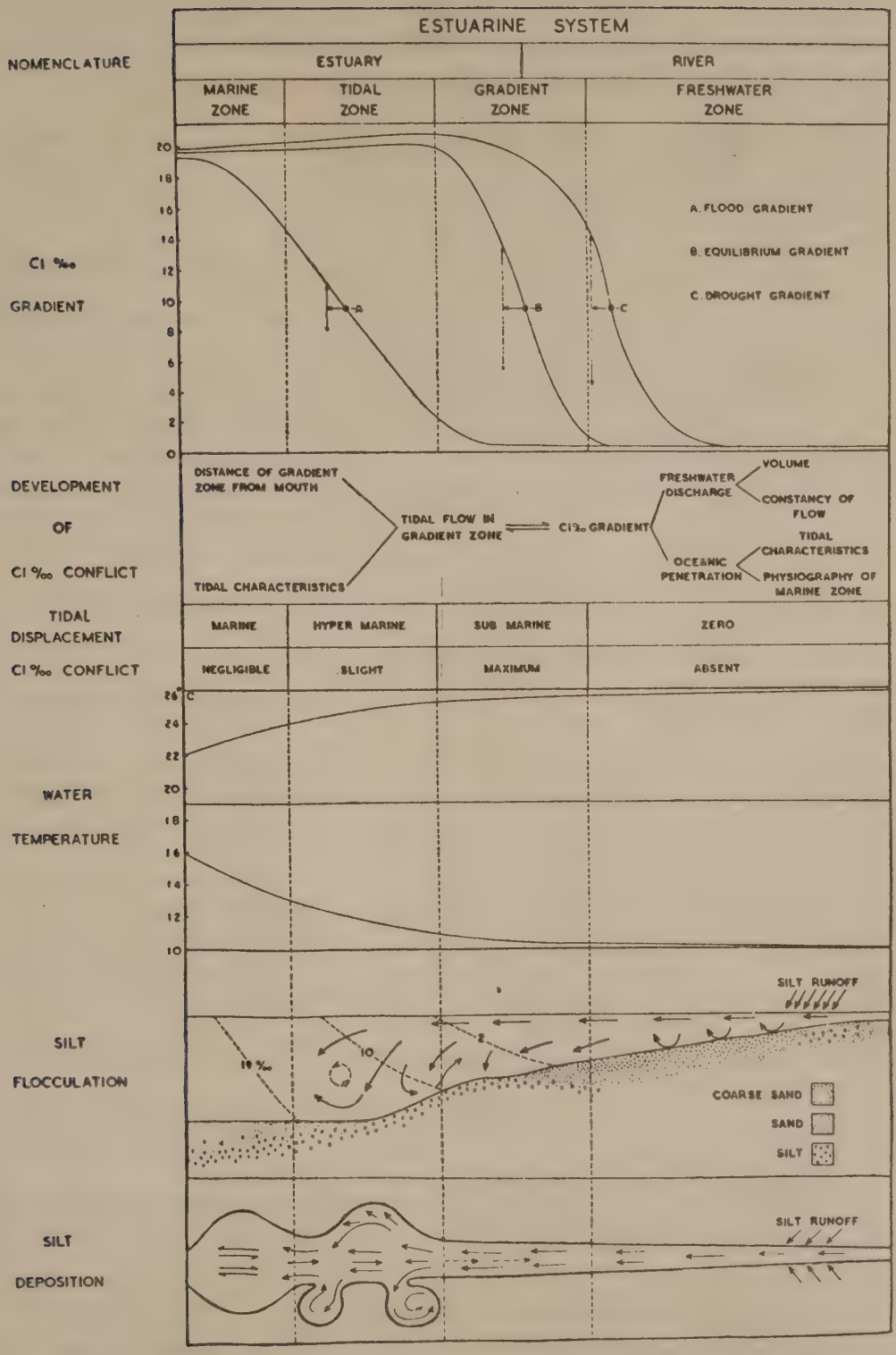

Figure 1. Diagram showing some of the zonal features of a composite Australian estuarine system. (after Rochford)

TABLE 2

	Firth of Forth	Norfolk	Holland	Elbe-Ästuar	Randers Fjord	Schwentine-Mündung	Untere Warnow	Ryck-Mündung	Frisches Haff	Finland
Cordylophora caspia (PALL.)	—	+	+	+	+	+	+	+	+	+
Nereis diversicolor DUM.	—	+	+	+	+	+	—	+	+	+
Eurytemora affinis et *hirundoides* ..	+	+	+	+	—	+	—	[1]	+	+
Acartia bifilosa GIESBR.	+	+	+	—	—	+	—	+	+	+
Mesochra lilljeborgi BOECK	+	+	+	—	—	—	—	+	—	—
Nitocra spinipes BOECK	+	+	+	—	—	—	—	+	+	—
Laophonte mohammed BL. et RICH. .	—	+	+	—	—	—	—	+	+	—
Tachidius brevicornis LILLJ.	+	+	+	+	—	+	—	+	+	+
,, *littoralis* POPPE	+	+	+	+	—	—	—	+	—	+
Cyprideis littoralis (BRADY)	+	+	+	—	—	—	—	+	—	—
Balanus improvisus DARW.	+	+	+	[2]	—	+	+	+	+	+
Heterotanais oerstedti (KR.)	—	[3]	+	—	—	+	+	+	+	—
Cyathura carinata (KR.)	—	+	+	—	—	+	—	+	—	—
Sphaeroma rugicauda LEACH	+	—	+	+	+	+	+	+	+	+
Idotea viridis (SLABBER).....	—	+	+	+	+	—	—	+	+	—
Iaera albifrons LEACH.....	+	—	+	+	+	+	+	+	+	+
Gammarus locusta (L.)	+	+	+	+	+	+	—	+	+	+
,, *duebeni* LILLJ.	+	+	+	+	+	—	—	+	[4]	+
Leptocheirus pilosus ZADD.	+	+	+	+	+	+	—	—	+	—
Corophium volutator (PALL.)	+	+	+	+	+	+	—	+	+	+
,, *lacustre* VANH.	—	—	+	+	—	—	+	—	+	+
Neomysis vulgaris (J. V. THOMPS.) .	+	+	+	+	+	+	+	+	+	+
Palaemonetes varians (LEACH).....	+	+	+	+	—	—	—	+	—	—
Embletonia pallida ALDER et HANC.	—	—	+	—	—	—	—	+	+	+
Membranipora crustulenta BASTER.	—	—	+	—	—	+	+	+	+	+
Victorella pavida KENT	—	—	+	—	—	—	+	+	+	—

[1]) *E. hirundo?*

[2]) *B. crenatus?*

[3]) *H. gurneyi* NORMAN.

[4]) *G. zaddachi* SEXTON.

Es bedeutet: + Vorkommen festgestellt,
— Vorkommen unbekannt.

The faunal characteristics of these various regions are roughly as follows: In the oligohaline zone are found many Cl-resistant fresh water organisms, while the polyhaline zone is invaded by many marine organisms. The mesohaline zone is characterized by a typical flora and fauna, and is, in Redeke's words, the "brackish water region 'par excellence'." Since the journal in which Redeke's paper appeared is not generally available to American workers, his table of the common animals of the mesohaline waters of northern Europe is reproduced here (Table 2). American workers in the field of estuarine ecology will recognize a number of familiar genera, and a few species, as occurring in their own waters.

An additional region, for which the term metahaline is here proposed (in conformity with the original terminology), is found in several parts of the world where shallow lagoons are connected with the sea, but subjected to excessive evaporation and inadequate fresh water alimentation. These metahaline regions have a fauna which is recruited, not from the sea, but from the mesohaline waters. Although there are not many species, their numbers are often large, and such areas may be highly productive. In the highly saline waters of the Laguna Madre and Baffin Bay on the Texas coast are found cyprinodontid fishes, a small bivalve, Anomalocardia cuneimeris, at least two polychaetes, (Nereis pelagica occidentalis and Polydora ligni), the barnacle Balanus eburneus, Acartia tonsa (a copepod), and two amphipods, Podocerus brasiliensis and Grandidierella bonneroides.

All of these are common species of near-by bays, indicating that such areas as the Laguna Madre belong to the brackish water system rather than to the system of inland salt and alkali ponds with their characteristic fauna of insect larvae, phyllopods and distinctive copepod suites. An apparently similar area in Europe, — at least in salinity characteristics, — is the Sivash, or Putrid Sea, a lagoon on the western side of the Sea of Azov, although the presence of fairy shrimp and insect larvae (Chironomids) suggests that the Sivash and the Laguna Madre are not strictly comparable (see Zenkevich, 1947, pp. 393-399, for a general account of the Sivash). Another region which is similar to the Laguna Madre is the Bitter Lakes region of the Suez canal, which has at least one species of amphipod (Podocerus brasiliensis) in common with the Laguna Madre as well as several other closely related forms (e.g., a very similar medusa).

2. The Hydrographic Climate

As an aid to the comparison of ecological conditions in various estuarine waters, some further scheme, including temperature characteristics, is essential. Unfortunately, we do not have adequate data for such important variables as phosphates and other nutrients, and sediment characteristics, to permit detailed comparisons for any given series of estuaries. However, the temperature and salinity characteristics of estuaries and brackish waters can easily be compared by the use of climagraphs adapted to the available hydrographic data. In their usual form, climagraphs are simply plots of monthly mean rainfall or humidity against temperature for the year, which gives a closed, irregular figure. Such climagraphs are useful in terrestrial ecology and require data which are usually available

for many parts of the world. Comparable hydrographic data consist of water temperature and salinity. Such data are available for many parts of the Atlantic and Pacific coasts of the United States, and for some other parts of the world (U. S. Coast and Geodetic Survey, various dates). When plotted as climagraphs, using the monthly average minima and maxima as well as the means, a series of three polygons is produced, and essential differences or agreements are easily demonstrated.

In figure 2 such a graph is presented for Key West, Florida, with the addition of the monthly extremes in red to indicate the widest possible use of the available data. Key West is selected for this sample because the ranges are somewhat restricted and the data can therefore be graphed in detail without requiring too much space. It is also of interest inasmuch as it indicates the environmental extremes under which reef corals can grow, if not flourish at their maximum.

If the "hydrographic climates" of Eastport Maine, Woods Hole and Key West are compared, it can be seen that Woods Hole, with its stenohaline but eurythermal climate, overlaps the temperature conditions of Key West during the summer months (at Woods Hole), and those of Eastport during the winter (Figure 3). The overlap between Woods Hole and Key West is brief, indicating that few organisms common to one area can be expected to flourish in the other; the zone of overlapping occurs at Beaufort, North Carolina. It may be pointed out that we knew this already from biogeographical evidence, but the presentation of the various averages in this manner provides further clues. For example, Deevey (1950), discussing the occurrence of certain species of hydroids on the northern coast of the Gulf of Mexico which do not flourish in temperatures above 20°C, has postulated a lowering of the annual average temperature at Key West by 5°C in Pleistocene times to permit the dispersal of these species into the Gulf. Examination of figure 3 will show that Galveston has average monthly temperatures favorable for these hydroids for five months of the year, whereas at Key West there might be, in an exceptional year, three months of temperatures averaging below 20°C. However, if the average were to be lowered 1.5 or 2°, the minimum averages would be even lower and there would probably be four or five months in which such extreme low averages would occur, so that the possibility of a given year having winters cold enough to permit migration of the hydroids past Key West would be increased. Thus, it does not seem necessary to postulate such a drastic change in temperature to explain the common occurrence of various organisms at Galveston and Woods Hole but absent from southern Florida.

The polygons for Beaufort and Galveston presented in figure 3 represent somewhat similar estuarine conditions, which would probably be classified as "polyhaline" by European workers. In figure 4 are presented the various averages found at Solomons, Maryland (in Chesapeake Bay), a "mesohaline" region, and at Eugene Island, Louisiana, an "oligohaline" situation near the mouth of the Atchafalaya River. While perhaps not "typical" in the sense of being "average", these localities show the further decrease in salinities from the near-oceanic conditions at Beaufort. The data for Beaufort, incidentally, are none too good, being the by-product of an investigation on scallops (Gutsell, 1930) carried out over

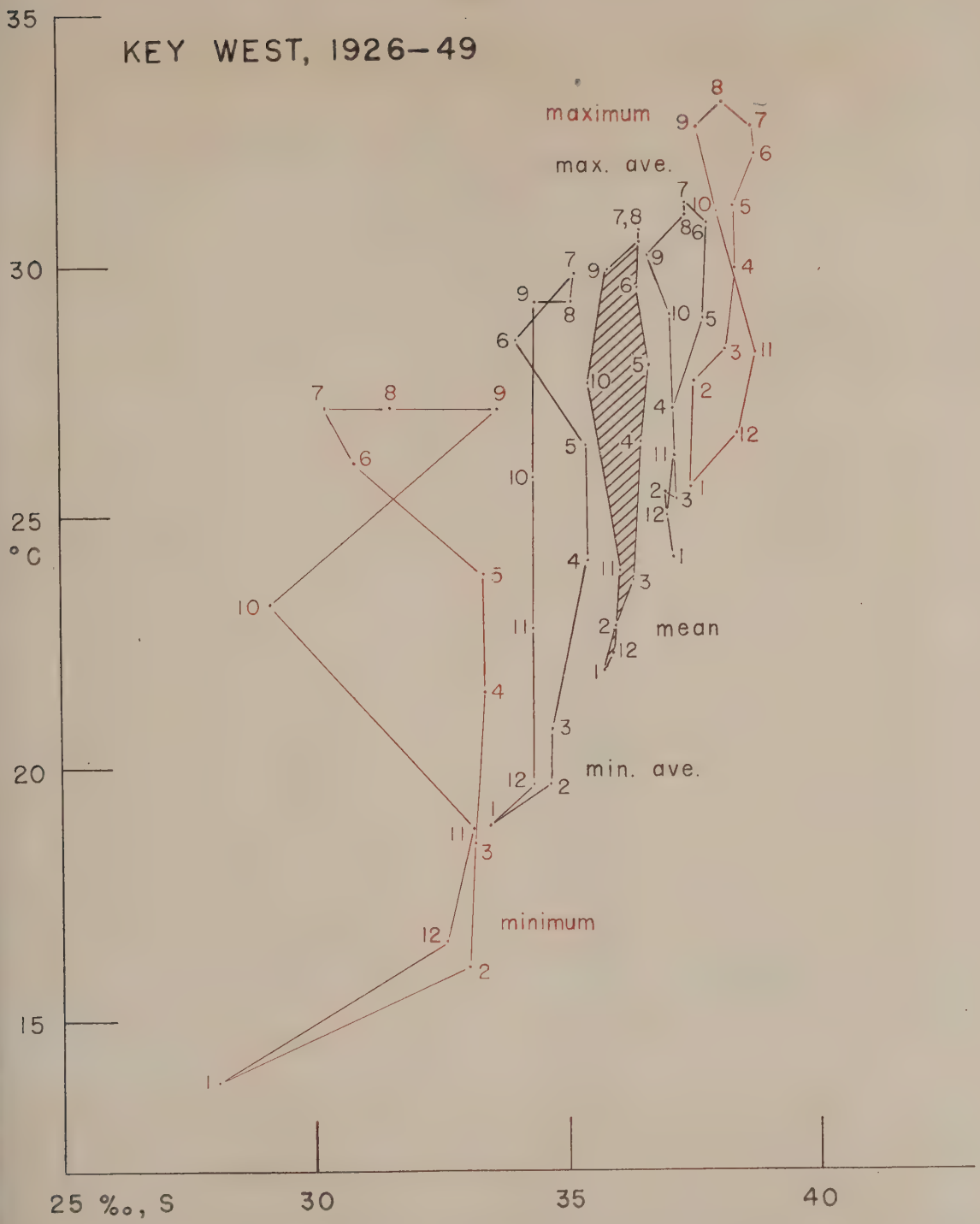

FIGURE 2. MONTHLY SALINITY AND TEMPERATURE MEANS AND EXTREMES, KEY WEST

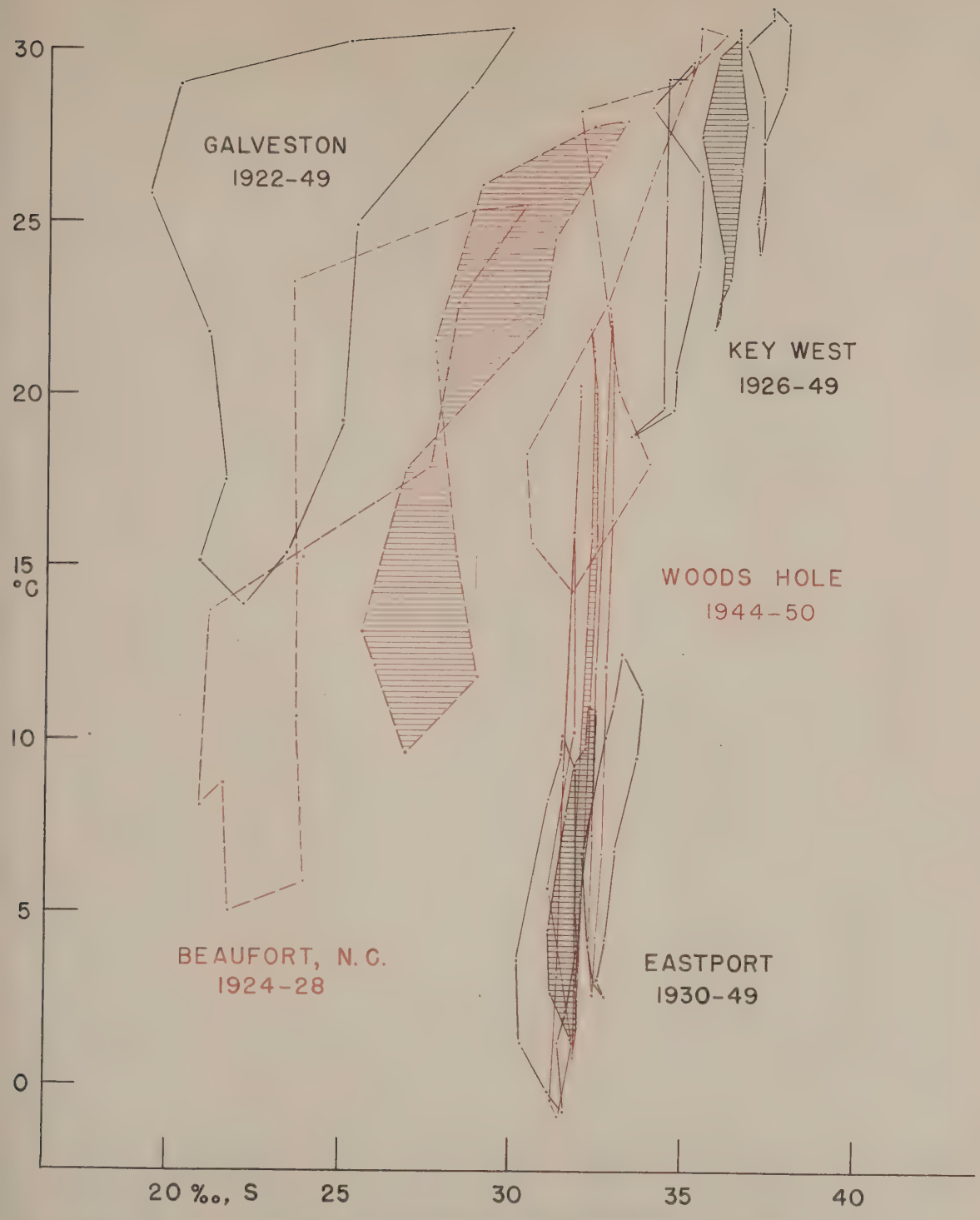

FIGURE 3. MONTHLY TEMPERATURE AND SALINITY MEANS FOR VARIOUS ATLANTIC AND GULF LOCALITIES

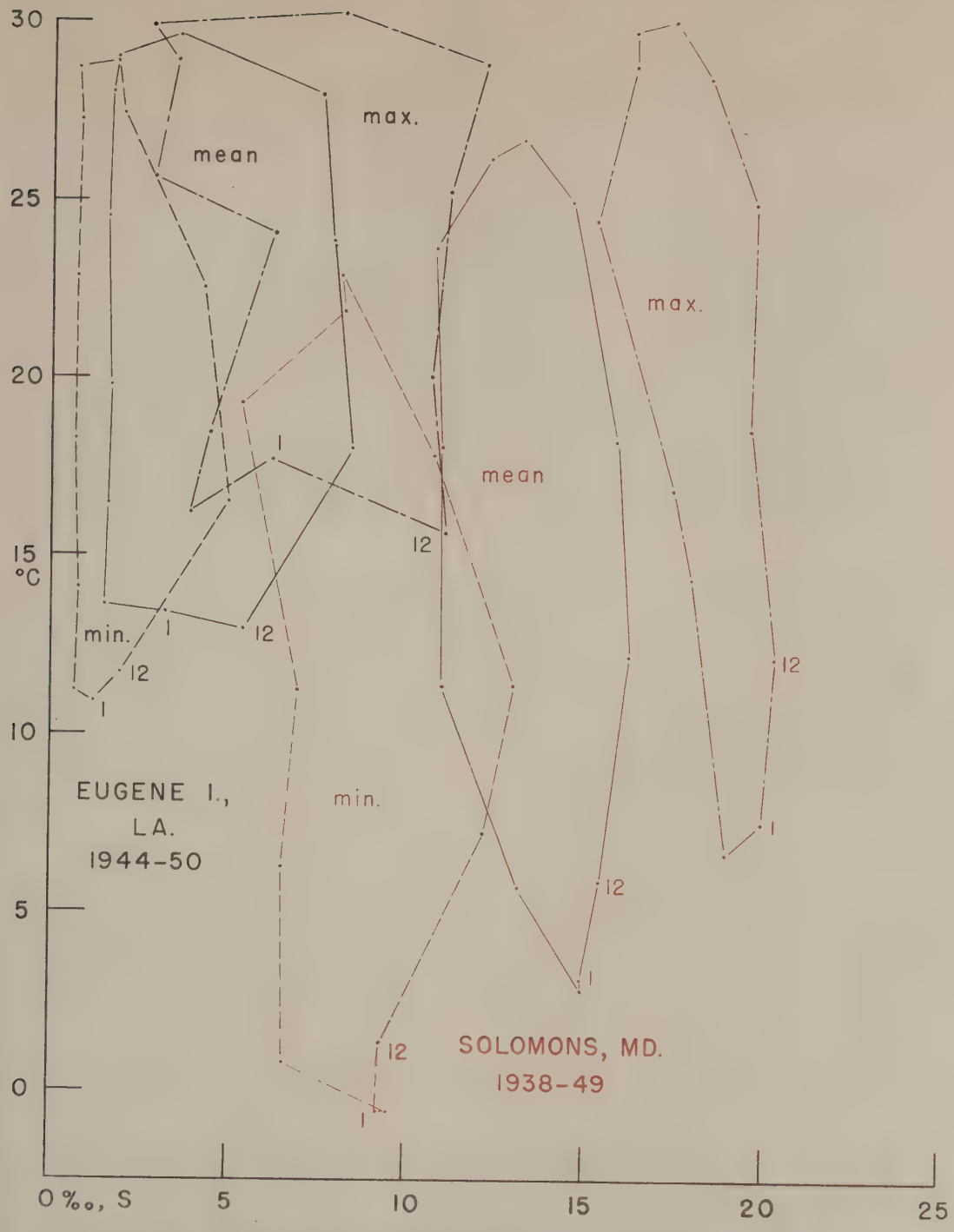

FIGURE 4. TEMPERATURE AND SALINITY MEANS FOR SOLOMONS, MD. (CHESAPEAKE BAY), AND EUGENE I., LA. (NEAR MOUTH OF ATCHAFALAYA RIVER)

a comparatively short period. Adequate data for Beaufort are yet to be obtained, but for that matter, it was not until 1944 that these comparatively routine data began to be gathered at Woods Hole, site of the oldest marine laboratory on the continent.

A sampling of the average conditions at various stations on the Gulf coast of North America, running the gamut from nearly fresh water to the hypersaline Laguna Madre, is presented in figure 5, together with the salinity spectrum classification. Of the various localities presented here, Copano Bay, Aransas Bay, the Gulf of Mexico off Port Aransas and the two parts of the Laguna Madre are the compilations of averages from a network of stations over various periods (Collier and Hedgpeth, 1950). The other localities are records of single stations, and cannot be accepted as typical of a general area, but only of the immediate vicinity of the gauging station. The graphs for Copano and Aransas bays indicate the difficulties of reconciling the seasonal regime of an estuary with the European scheme of classification. While such terms as mesohaline and polyhaline are indeed useful, they must be used with full realization of their limitations.

Rochford (1951) has suggested a classification of Australian estuaries according to their prevailing characteristics. An estuary whose normal condition approximates the marine zone of the generalized estuary (see fig. 1) is classified as a "marine dominated system", etc. The "gradient dominated system" appears to be roughly equivalent to the polyhaline zone as used by Dahl. This scheme admits such categories as "summer flood fresh-water dominated" and "atidal" systems. The latter category seems to approximate some of the estuarine conditions found on the Gulf Coast, with lower mean temperatures, although there are not enough data in Rochford's preliminary paper to permit detailed comparisons.

Thus the difficulties of comparing diverse environments on the basis of terminology, even when it consists of descriptive phrases of the type proposed by Rochford, are apparent. The salinity spectrum terminology is open to the same objections. In his work on the bays near Rio de Janeiro, de Oliveira (1948) seems to have a somewhat higher scale of value for his salinity spectrum than do European workers, since he refers to waters ranging to 33.0 o/oo as "mesohaline." Examination of his faunal lists suggest that the Baia de Guanabara must have characteristics very similar to some estuarine waters along the Gulf Coast, but in the absence of monthly temperature and salinity means, the comparison cannot be made.

While no serious effort has been made at this time to gather together data of the required sort for many parts of the world, a few interesting sets of averages for diverse environments have been collected. Some of these are presented in figure 6 as further illustrations of the use of this method. It is especially interesting to compare the graphs for Willapa Bay and the Oosterschelde (data for the latter from Korringa, 1940). Both of these bays are noted for their oyster culture, although the species are different: Ostrea edulis in Holland, Ostrea lurida and Crassostrea gigas in Willapa Bay. The graphs for Port Erin and La Jolla indicate stations with similar salinity characteristics but completely

separate temperature regimes. An example of an estuary near the tropics which lacks the pronounced seasonal regime of a temperate zone estuary is that at Hilo, Hawaii. This scheme is also useful for comparing the different parts of an estuary, e.g., the two parts of Willapa Bay in the figure. It can also be adapted to different depths in the same locality. Eventually it may be possible to construct such graphs summarizing the mean tolerances of certain organisms.

It does not seem advisable to propose any further terminology for these graphs. Since we tend to use our own experience, or the conditions with which we are most familiar, as a frame of reference, each worker will probably set up his own criteria as a point of departure. In the series of graphs which illustrate this preliminary paper, for example, Key West is the frame of reference for the oceanic conditions. Further, no attempt is made to adapt these patterns to the various schemes of temperature zonation which have been proposed. Terminology too often conceals more than it reveals, especially when applied to such a complex and variable situation as an estuary, and our present knowledge does not justify any terminological straitjackets.

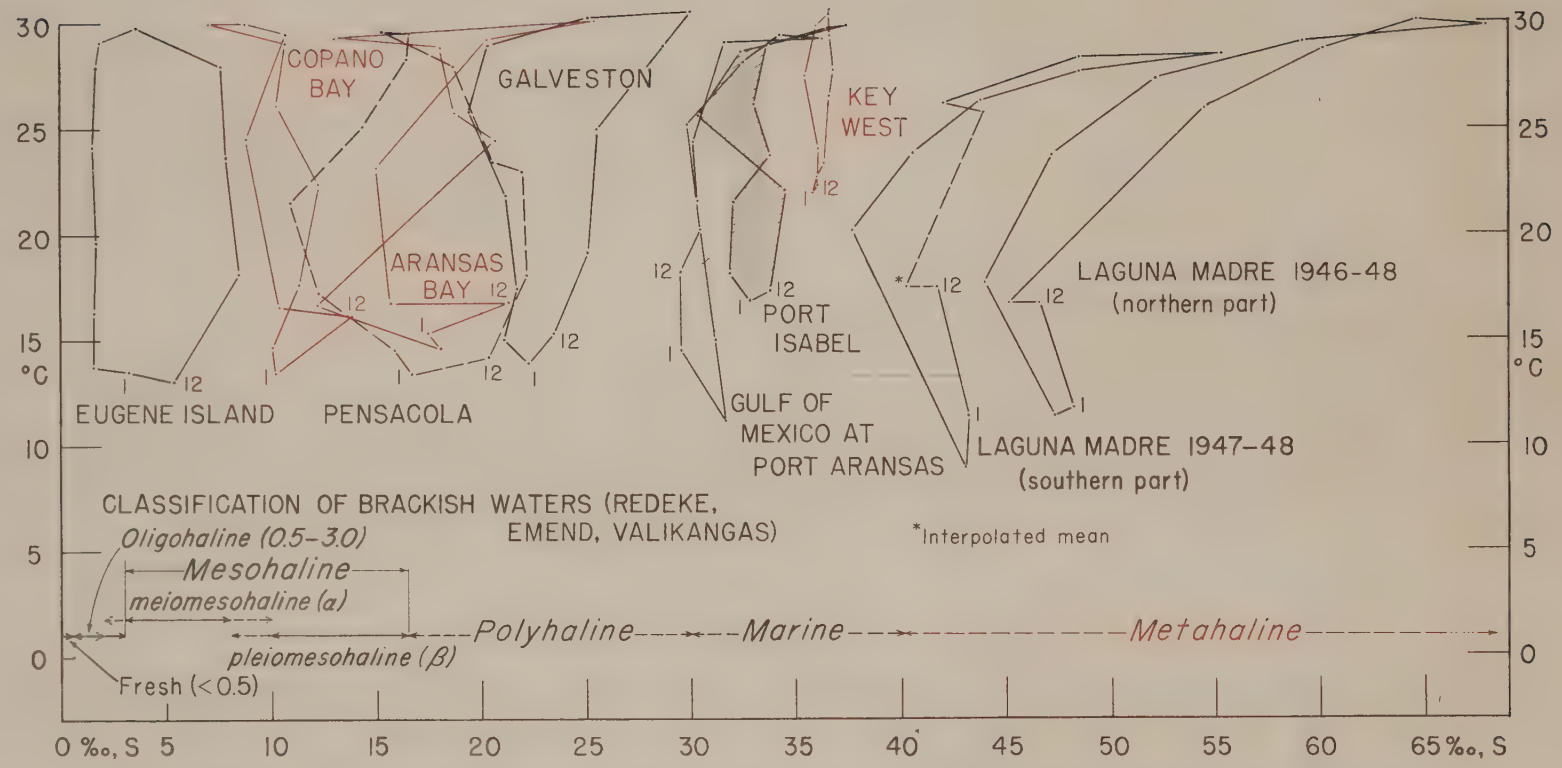

FIGURE 5. COMPARATIVE HYDROGRAPHIC CLIMATES, GULF OF MEXICO

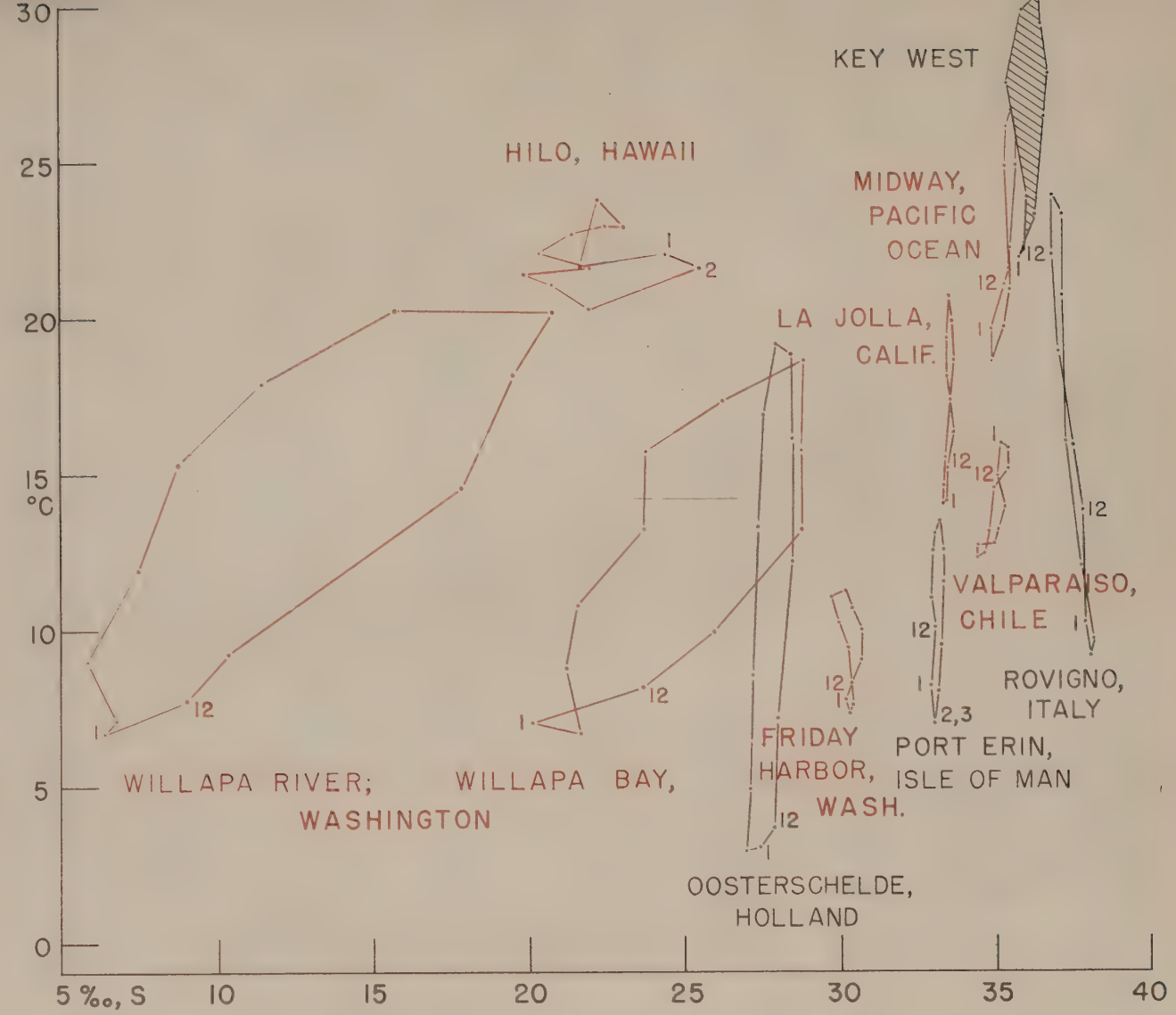

FIGURE 6. COMPARATIVE HYDROGRAPHIC CLIMATES

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PALEOECOLOGY AND DEEP SEA EXPLORATION

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Oceanographic and geological exploration of the deep sea far from continental shores has not advanced continuously since its beginnings in the Challenger Expedition nearly 80 years ago, but has tended to run in cycles. Each new cycle of expeditions has received its impetus chiefly from the development of new tools for exploration - new means for extending the senses of the scientist into regions that he may never see.

The last great cycle of ocean exploring expeditions before World War II took place in the 1920's. Among these, the voyages of the Meteor, Willebrod, Snellius, Carnegie, Dana, and Discovery II will long be remembered. From 1930 until 1946, submarine geological research was largely confined to development of new methods and their application in studies of near shore areas. New instruments developed or refined during the last 20 years include among others, continuously recording echo sounders, underwater cameras, equipment for taking long cores of bottom sediments, rock dredges, current meters for use from a moving ship, systems for seismic refraction and reflection studies of ocean bottom structures, nets for relatively high speed sampling of animal populations at great depths, temperature-depth recorders, methods for determining chemical conditions in situ in the sediments, and electronic aids to navigation. These represent great advances in techniques for exploration of the ocean and of what lies beneath the ocean floor.

Some of these devices were used on the high seas prior to and during World War II, notably on board the research ship Atlantis of the Woods Hole Oceanographic Institution, and on Naval vessels. But the renaissance of deep sea exploration on a large scale came in 1947, when the Atlantis, under Maurice Ewing, started her systematic investigations of the Mid-Atlantic Ridge, and the Swedish Deep Sea Expedition, headed by Hans Pettersson, began a voyage around the world to exploit the powerful new coring methods developed by B. Kullenberg. At about the same time, the U. S. Navy Electronics Laboratory began geological and other oceanographic investigations far from shore in the Pacific. During the summer and fall of 1950, the Scripps Institution of Oceanography and the U. S. Navy Electronics Laboratory jointly carried out on two ships an expedition to the eastern and central tropical Pacific. This "Mid-Pacific Expedition" was followed in the summer of 1951 by the "Northern Holiday Expedition" to the northeastern North Pacific, on

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1/ Contribution from the Scripps Institution of Oceanography New Series No. 549.

the Scripps research ship, Horizon.[2/] At the present time, the Danish ship Galathea, and the British Challenger, like her famous namesake a corvette of the Royal Navy, have been at sea for many months on voyages of scientific exploration which will take them around the world.

For the geologist and paleontologist these voyages of exploration are serving a twofold purpose. By yielding information on conditions in the present oceans and on the character of the sediments now being laid down, they will add in many ways to our understanding of the historical record locked in sedimentary rocks on land. This use of the present to shape keys to the past has long been recognized as one of the primary justifications of oceanographic research. But modern deep sea exploration is doing more than this - it is producing new and far-reaching insights into the geologic history of that 71% of the earth which lies under water. The results achieved to date, though scattered and fragmentary, show that much greater understanding must be gained about the geology of the ocean floor before a realistic geologic history can be written of the earth as a whole. Until recently geologists have comforted themselves with the belief that the ocean basins have been more stable than the land, that little of geologic interest has happened there, that the broad expanses of the abyssal floor are a monotonously uniform sea of mud over great distances, and that little could be learned about the earth's history from those superficial layers of the ocean bed which were accessible to study. But they are now finding that the oceans have been the scene of intense and varied geologic activity, that the shape and structure of the sea floor are remarkably complex, that within the upper layers of the sediments in certain areas we have an unrivalled archive containing detailed records of ocean climates during the last few million years, and that elsewhere there are Mesozoic and Tertiary sediments and fossils lying exposed on the sea bottom.

In the following paragraphs, examples are given of new findings on present day conditions, and of new clues to the geologic history of the oceans selected because of their special interest to paleontologists and ecologists. These are largely based on the results of the Mid-Pacific Expedition but similar examples could be drawn from the records of any of the post-war expeditions.

NEW DATA ON CONDITIONS IN THE PRESENT OCEANS

Deep-Scattering Layer.-- Echo sounding records and collections with the deep-water trawl show that the organisms living in the bathypelagic zone of the open ocean are greater in number and more complex in behavior than had previously been supposed. It is common to find in a single net haul dozens of individuals of a species which was formerly known from only a few isolated examples. Echo sounder records of the so-called deep scattering layer often show as many as five or six separate sound-reflecting layers, at depths of 20 to 400 fathoms. All of these exhibit vertical motion correlated with variations in light intensity. When it is raining, the layers rise nearer the surface; when the sun comes out again, the layers go deeper

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2/ These two expeditions were supported by the Office of Naval Research and the Bureau of Ships of the Navy Department, the U. S. Geological Survey and the Institute of Geophysics, University of California.

At sunset, the echo sounder records a vertical migration up to the sea surface of some of the organisms making up the layers. But some remain behind and do not rise, so that some layers observed in the daytime are still present at night, at about the same depths but in lower concentration. At times the discrete layers disappear and sound is scattered continuously from all depths between the surface and several hundred fathoms. The population density of the bathypelagic zone is not uniform over the ocean, nor does it remain constant at any one locality. A rich haul may be taken at one time in an area which is nearly barren a few weeks later. The region of the equatorial currents teems with a great variety of animals, while farther north sparser populations are found. At night when the ship was hove to in tropical waters, as many as a thousand squid, hundreds of dolphins, and countless lantern fish and sauries were attracted by a light hung overside. In the daytime, the echo sounder recorded many dark blobs, probably representing echoes from schools of fish or squid.

Equatorial Counter Current.— With the electrokinetograph developed at Woods Hole, it is now possible to measure surface currents in the open sea from a moving ship. On the Mid-Pacific Expedition, this instrument was used to study the equatorial counter current and the northern and southern equatorial currents. Contrary to previous oceanographic doctrine, it was found that these currents do not flow exactly east and west in continuous parallel bands, but that there is a pattern of giant eddies, of the order of 1000 miles in diameter, around which the waters move, often at velocities of two knots or more, in elliptical or sinuous paths. There is evidence of a very considerable vertical component of motion in the upper water layers - these vertical motions maintain the fertility of the subsurface layers and thus account for the high population densities in the latitudes of the equatorial counter current.

Topographic Control of Sedimentation.— Even in the abyssal depths of the ocean far from shore, irregularities of bottom topography exercise a profound control on the distribution of sediments. The tops and sides of topographic highs only a few hundred fathoms above the general floor level are commonly bare of Recent sediments or have only a sparse veneer of coarse material. In areas of irregular bottom topography, closely spaced samples often differ markedly one from another. Where a source of coarse material exists on a topographic high, layers of coarse grained sediment are frequently found in cores from neighboring deeper areas. For example, rounded volcanic pebbles up to several centimeters in diameter are a major constituent of the bottom layer of a core collected at 2050 fathoms in the middle of a relatively flat deep embayment in the submerged "Mid-Pacific Mountains", some 900 miles west of Hawaii. These have almost certainly been carried down from 1000-fathom deep summit of a guyot about 60 miles distant.

The existence of bottom currents, capable of moving sand-sized materials, over topographic highs even at very considerable depths is indicated by a bottom photograph showing ripple marks in Globigerina sand on the 750-fathom summit of "Sylvania Guyot", northwest of Bikini Atoll.

Chemical Conditions in Deep Sea Sediments.— Shipboard analyses by S. C. Rittenberg and R. Morita of freshly collected cores show that the chemical environment in pelagic sediments is relatively acid compared to the overlying sea water, and highly oxidizing. In red clay, the pH below the surface layer ranges from 7.0 to 7.5; Globigerina oozes are slightly more alkaline, ranging from 7.15 to 7.6. There is some tendency for the pH to decrease with depth in the cores, but this is often obscured by stratification. The oxidation reduction potential is always positive and increases with depth in the cores, ranging from about - .375 volt (relative to the standard hydrogen electrode) in the uppermost layers, to as much as .685 volt in layers 400 centimeters below the bottom surface.

"Free" ferric iron, perhaps in the form of colloidal ferric hydroxide, is present in amounts ranging from 6 mg/ml of sediment near the surface of red clay cores to 12 mg/ml near the bottom of these cores. Less than 1 mg/ml is found in Globigerina oozes of high calcium carbonate content. Free silica in the interstitial waters of the sediments often amounts to more than 10 mg/liter in red clays, and to less than one mg/liter in Globigerina oozes.

Both aerobic and anaerobic bacteria were found by Morita living three meters or more beneath the surface of the sediments, even in waters more than 3000 fathoms deep. These include nitrate reducers, starch hydrolizers, gelatin liquefiers and sulfate reducers.

NEW DATA ON THE GEOLOGIC HISTORY OF THE OCEANS

In the above paragraphs, examples are cited of new information on conditions and processes in the present ocean. Let us now turn to some of the results of modern deep sea exploration which are beginning to elucidate the geologic history of the ocean basins. Examples will be given from the results of sediment coring, dredging on guyots, and seismic refraction studies.

Stratification and Fossils in Cores.— Many of the cores taken on the Mid-Pacific Expedition are highly stratified, with alternating layers of red clay, calcareous oozes, and weathered volcanic material. Because of the extremely slow rate of deposition of deep sea sediments, this stratification in many instances represents a record of geological events occurring in the Pacific over hundreds of thousands, or even millions of years. The presence of alternating layers of red clay and Globigerina ooze in cores from the Equatorial Atlantic has been interpreted by several workers as reflecting Pleistocene and later changes in ocean temperatures. Such alternating layers are also found in the Pacific but interpretation is complicated by the fact that at least in some cores deposition of the red clay layers has apparently been interrupted by the intermittent and relatively rapid deposition of calcareous material transported downward from topographic highs.

Layers of weathered volcanic ash are common in many cores. The number, thickness and position of these layers are widely variable from one core to another, indicating the presence of numerous local centers of vulcanism in the Pacific during the Pleistocene.

Several cores collected on the Mid-Pacific Expedition have been found by M. N. Bramlette and F. B. Phleger to contain the remains of Tertiary and Cretaceous pelagic Foraminifera, including such genera as Gumbelina, Gumbelitria and Globotruncana. In some instances, these are mixed with Recent Foraminifera, or layers of Recent and fossil species occur in the same core. In one core of calcareous ooze interbedded with red clay only Cretaceous and probably earliest Tertiary Foraminifera are found. Detailed exploration and sampling of the bottom region in which these cores were collected might demonstrate the existence of fossil oozes exposed on deep topographic highs which have been areas of non-deposition since Mesozoic or Tertiary time.

Dredging on Guyots.-- In his classic paper on "Drowned Ancient Islands of the Central Pacific", Hess proposed the hypothesis that the flat summits of guyots were cut by wave erosion during pre-Cambrian time, and that they have since been slowly submerged, primarily because accumulation of sediments has raised the sea level. Dredging on the nearly flat tops of the guyots which form the summit peaks of the Mid-Pacific Mountains confirms Hess' hypothesis that these surfaces were cut by wave erosion, and in addition gives striking evidence as to the approximate time of wave cutting and submergence of the guyots. Rounded basaltic pebbles, cobbles and boulders were dredged from the summits of six guyots at depths between 700 and 1000 fathoms. Moderately well cemented sandstone made up of volcanic debris, and limestone closely resembling beach limestone formed on present-day atolls, were dredged from two of these. According to E. L. Hamilton, fossils associated with the limestone include several genera of reef corals, mollusks and an echinoid, all of late Cretaceous age.

Seismic Measurement of Sediment Thickness.-- As pointed out by Kuenen in his "Submarine Geology", many lines of evidence indicate that the amount of sedimentary materials stripped off the continental platforms by erosion should form a sedimentary blanket averaging at least three kilometers in thickness over all the oceans. This is calculated without any pore space. If the pore space normally found in sedimentary rocks on land is taken into account, and if we add the great thickness of volcanic ash which has probably been produced in the deep sea itself, the average thickness of sediments on the ocean floor should be more than four kilometers. This computation is in marked contrast to the thickness actually found in seismic refraction studies by R. W. Raitt on the Mid-Pacific Expedition. Although the sediment thickness cannot be determined exactly from Raitt's data, a value of 500 meters appears reasonable. This is less than one-eighth of the computed thickness. It is fascinating to speculate that some great event occurred in the Central Pacific in relatively late geologic time, which destroyed all traces of earlier deep-sea sediments.

OBSERVATIONS PERTAINING TO THE PALEOECOLOGY OF THE BLASTOIDS

by

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In an attempt to compile an annotated bibliography of the paleoecology of blastoids 110 papers concerning blastoids, including several by the senior author, were reviewed. Since not one significant reference to blastoid paleoecology was found in this literature, the original assignment could not be fulfilled, and we offer instead a summary of our personal observations pertinent to blastoid paleoecology, together with some tentative conclusions.

Perhaps the most helpful papers are not those dealing primarily with blastoids but some concerning Paleozoic crinoids. Blastoids are an extinct class of stalked echinoderms, exclusively Paleozoic, and because their fossilized remains are often associated with those of the crinoids, they are presumed to have lived under somewhat similar conditions. Lowenstam (1948) has shown that Silurian crinoids lived in more than one environment and this was doubtless true of the crinoids of the other Paleozoic systems. The complexity of the problem is well illustrated by noting the habits and distribution of modern crinoids. Recent crinoids range in latitude from 81° North to 52° South, and from intertidal levels to depths of 15,600 feet, although the bathymetric range of individual species is usually somewhat restricted; some are stalked, some are free; there are important differences in the locomotion of the free forms; some creep, some swim; most are gregarious but some are solitary. Assuming that Paleozoic crinoids were as varied in their habits as their descendants (but of this there is no absolute guarantee), the difficulties in interpreting their paleoecology are at once apparent. The extinct blastoids present a more difficult problem in that we can not derive help from a study of living forms, but are entirely dependent on the evidence from the lithology and inferences that can be made from studying their organic associations.

NOTES ON THE SEDIMENTOLOGY AND PALEONTOLOGY OF SOME OF THE FORMATIONS IN WHICH BLASTOIDS OCCUR

During the past twenty years the senior writer has had the good fortune to collect fossils at a good many localities where blastoids are numerous or well preserved. Some of these localities are well known from the literature but others are little known and some are unrecorded. In our collecting we have given close attention to the stratigraphic occurrences of the various blastoid species but we have not made a conscious effort to make observations of an ecological nature. Nevertheless, certain observations seem pertinent to the problem at hand and are recorded below. The occurrences are arranged stratigraphically but no attempt is made at completeness.

SILURIAN

Beech River formation (Niagaran) of Tennessee.— Troosticrinus reinwardti is a common fossil in the Beech River formation west of Decaturville, Tennessee, where it is associated with the crinoids Lampterocrinus, Pisocrinus, Lyonicrinus, and Eucalyptocrinites, the cystoid Caryocrinus, and the brachiopods Atrypa, Parmorthis, Uncinulus, and Leptaena. The blastoids are preserved in bluish-white calcite and show little evidence of wear. Weathering frees them from their matrix and, as they lie about the surface and roll down the slopes, the faunas of the various layers become mixed. The blastoid-producing portion of the formation is a blue-gray marl which includes beds of nodular limestone; it does not seem to have significant vertical variations in lithology but some layers are rich in other species, indicating changes in ecological conditions from time to time. This suggestion seems to be borne out by the occurrence of the robust Eucalyptocrinites and the tiny Pisocrinus in the same formation, but not necessarily occurring in the same layers. Eucalyptocrinites might be interpreted as indicating rough-water conditions, whereas Pisocrinus might indicate quieter and perhaps slightly deeper water.

DEVONIAN

Mid-Devonian formations of Louisville, Kentucky, and southern Indiana.— Richly fossiliferous Mid-Devonian rocks in the vicinity of the Falls of the Ohio River at Louisville, Kentucky, and in adjacent southern Indiana are famous for their well preserved corals, brachiopods, crinoids, and blastoids.

The Jeffersonville limestone of Onondaga age has been referred to as a coral reef but actually is divided into three ten-foot zones of which, in our opinion, only the lower one could accurately be described as a coral biostrome. The upper ten feet of the formation, which lies within the Paraspirifer acuminatus zone, has yielded a number of well preserved blastoids belonging principally to several species of Nucleocrinus and Codaster. About eight feet below the top of the formation there is a shale parting that has yielded Codaster alternatus and perhaps other species of the genus, and two feet above this in the limestone is a zone referred to as the Nucleocrinus bed. Codaster pyramidatus and C. americanus have also been found in limestone in the upper Jeffersonville.

The overlying Sellersburg formation of Hamilton age has yielded a number of echinoderms. Most of the blastoids have come from the Beechwood member (mid-Hamilton) at the top of the formation. The Beechwood is medium to dark gray, fine-grained to coarse-grained and crinoidal, and near the base phosphatic pebbles and phosphatic fish remains are common. Nucleocrinus is common and Codaster occurs sparingly in the crinoidal facies of the member.

There is much evidence that the middle Devonian formations of this area were deposited in comparatively shallow water. The thinness of the combined Onondaga-Hamilton interval and the presence of several minor disconformities, e.g., the one at the base of the Beechwood, indicate slow deposition in water so shallow and so close to the profile of equilibrium that a thick column of sediments could not accumulate, and that from time to time the sea floor was

brought above the base level of deposition, thus permitting removal of some of the previously deposited sediments and the consequent development of diastems in the accumulating sediments. A shallowly submerged submarine bank, related to the positive Cincinnati arch, would have favored the growth of the coralline biostromes that are observed on both sides of the arch. The blastoids are believed by the writers to occur in non-reef facies.

Strata of Hamilton and Tully age, New York, Ontario, Michigan, and Iowa.— The late Hamilton Ludlowville and Moscow formations and the overlying Tully in western New York, and their equivalents in southwestern Ontario, northern Michigan, eastern Wisconsin, and eastern Iowa have yielded quite a number of well preserved blastoids. With perhaps a few exceptions, blastoids are not abundant as compared with the brachiopods, corals, and bryozoans with which they are associated. It seems noteworthy that this stratigraphic interval is, on the average, very shaly and very dark. Most of the blastoids occur in the dark argillaceous limestone members of the formations but quite a number have come from dark calcareous shales.

The Centerfield limestone member at the base of the dark Ludlowville shale in western New York has yielded Devonoblastus leda, Nucleocrinus lucina, N. priebei, and Pleuroschisma hibbardi. The equivalent Hungry Hollow formation of southwestern Ontario carries Codaster canadensis, Devonoblastus leda, Nucleocrinus elegans, Pentremitidea cummingsi, P. decipiens, P. dotis, P. nuciformis, P. ovalis, P. preciosa, Pleuroschisma lycorias, and P. ontario. The formation contains a thin brown crinoidal limestone at the base overlain by three or four feet of dark blue-gray calcareous shale (referred to as the coral bed). Most of the blastoids have been collected from the calcareous shale but they show little evidence of deformation by compaction. Their associates in this bed include a rich fauna of Cystiphyllum, Favosites, Heliophyllum, Fenestella, Athyris, Cyrtina, Mucrospirifer, and Phacops.

Slightly younger in age is the Norway Point formation of Michigan which contains Codaster alatus, Pentremitidea clavatiformis, and P. filosa. The formation includes brown and gray limestones and calcareous shale.

The Tichenor limestone (upper Ludlowville) of western New York has produced Codaster canadensis, C. curtus, Devonoblastus leda, Nucleocrinus powelli, Pentremitidea eriensis, P. goldringae, P. preciosa, and Pleuroschisma lycorias. The Tichenor member includes a thin crinoidal limestone at the base and some associated shales (Cooper, 1930). We have studied a number of specimens from the Tichenor which were embedded in a matrix of dark gray argillaceous limestone; Reimann (1945) collected one slightly crushed specimen from the upper shaly portion of the limestone. He (Reimann, 1935) stated that Pentremitidea goldringae occurs in all of the exposures of the Pleurodictyum zone of the Wanakah shale member which underlies the Tichenor member.

The Kashong shale member of the Moscow formation has yielded Devonoblastus leda, D. calyce, Eleutherocrinus whitfieldi, Nucleocrinus lucina, N. powelli, Pentremitidea eriensis, P. whitei, Pleuroschisma, lycorias, and Schizotremites kopfi. The specimens that we have studied are dark and occur in a matrix of dark blue-gray calcareous shale.

The Thunder Bay formation (Cooper, et al., 1942) of northern Michigan consisting of "gray and bluish argillaceous limestones and gray calcareous shales, containing many crinoids and blastoids....." (Warthin and Cooper, 1935) has produced numerous beautifully preserved blastoids including Codaster canadensis, C. gracilis, Nucleocrinus meloniformis, N. elegans, N. obovatus, Pentremitidea americana, P. bassleri hastula, and P. milwaukeensis. To judge from several lots of blastoids that were collected here, Codaster gracilis appears to be especially abundant.

Isolated outcrops of Devonian rocks in the vicinity of Milwaukee, Wisconsin, have yielded a few blastoids from the dark shaly layers of zone C of the Milwaukee formation. The fauna includes Nucleocrinus obovatus, Pentremitidea filosa, and P. milwaukeensis and is closely related to the blastoid fauna of the Thunder Bay formation of Michigan. The Milwaukee blastoids occur closely associated with brachiopods, corals and bryozoans.

The Cedar Valley limestone of Iowa has yielded Codaster subtruncatus and Nucleocrinus meloniformis from shaly limestones at Buffalo, Iowa, and Nucleocrinus bondi and N. obovatus from harder brown limestone. This blastoid fauna is a close correlative of the Thunder Bay limestone fauna of Michigan.

MISSISSIPPIAN

Iowa-Missouri Area

Chouteau (Kinderhookian) of northern Missouri.— Blastoids occur sparingly in most outcrops of the Chouteau limestone in central and northeastern Missouri. The largest number of specimens that we have collected at any one locality came from the upper part of the Chouteau limestone in the old railroad quarry at Sweeney in Cooper County, Missouri. The rock is blue-gray, dense, fine-grained, nodular, has a subconchoidal fracture and a tendency to weather drab or light buff. Peck has collected more intensively at this locality than we have and he (Peck, 1938) has identified Codaster blairi, Cryptoblastus roemeri, Cryptoblastus conoideus, and Cryptoblastus missouriensis from this locality. Typical of the associated fossils are Amplexus, Actinocrinites, Platycrinites, Fenestella, Rhombopora, Chonetes, Rhipidomella, Avonia, Spirifer, Reticularia, Schizodus, Bellerophon, and Phillipsia.

Hampton formation (Kinderhookian) at LeGrand, Iowa.— Limestone quarries at LeGrand in central Iowa have long been famous for their fine crinoids and, to a lesser extent, their blastoids, having produced well preserved Orophocrinus, O. fusiformis, O. legrandensis, and Cryptoblastus. Most of the blastoids are found in the Orophocrinus zone (Laudon, 1931), an eleven-foot zone in the lower half of the Hampton formation. The blastoids occur with an abundant coral, crinoid, and brachiopod fauna which includes Zaphrentis, Rhodocrinites, Cactocrinus, Platycrinites, Schellwienella, Rhipidomella, Dielasma, Spirifer (numerous species), Bellerophon, Capulus, and fish teeth. The Orophocrinus zone has been correlated with the Wassonville member of the Hampton formation (Laudon, 1931) and is assigned a stratigraphic position in the Kinderhook that is slightly younger than the Chouteau (Laudon, 1937). The Orophocrinus zone includes hard "crystalline"

ledges of very fossiliferous crinoidal, dolomitic limestone interbedded with thinner layers of finer grained less fossiliferous rock. The rock is prevailingly yellow-gray but some portions are buff. A large percent of some of the ledges of coarse textured material appears to be recrystallized calcite with numerous smaller areas of buff, slightly silty dolomite. A microscopic examination of the finer grained, silty appearing beds shows that they are principally composed of tiny dolomite crystals with some included calcitic shell fragments. Occasional specimens of blastoids with the pinnules preserved are found in the fine grained layers, but most of the specimens occur in the coarser textured "crinoidal" beds and are devoid of pinnules. It would appear that the crinoidal layers accumulated in more agitated, perhaps shallower, waters than the fine-grained dolomite. The blastoids range in size from young to mature forms and appear to represent a normal self-perpetuating population. The calyces appear to be little worn and, whereas they may have suffered some transportation, it is believed that they are found essentially where they lived and died. They probably preferred the more agitated water of the crinoidal facies to the quieter areas where the finer grained sediments were allowed to accumulate.

Burlington limestone (Osagian) of Missouri and Iowa.-- The Burlington limestone of southeastern Iowa and of Missouri is world famous for its beautifully preserved crinoids and blastoids. Such an unusually high proportion of the formation is composed of the dissociated remains of crinoids and blastoids that it can be identified by its crinoidal character, some of the beds being true crinquinas. We have collected hundreds of blastoids from numerous localities in Iowa, Missouri, Arkansas, and Oklahoma and of these we have selected two widely separated localities in Missouri as illustrative.

At Hannibal in northeastern Missouri, where the Burlington is quarried extensively, it attains a thickness of 120 feet in the bluffs of the Mississippi River at Lovers Leap south of town (Moore, 1928). Beds of fossiliferous limestone occur throughout the formation but inasmuch as a variety of rock types occurs, each type doubtless representing a slightly different environment of sedimentation, we will restrict our observations to about ten feet of crinoidal limestone in the lower part of the formation. The extensive workings of the Atlas Portland Cement Company, south of Lovers Leap, expose a 12-foot bed of massive, light gray, pure, crinoidal limestone known to quarrymen as the white ledge. Yellow-gray to buff dolomitic crinoidal limestones immediately below the white ledge and in the upper part of Rowley's Orophocrinus zone (Rowley, 1908) abound in Cryptoblastus melo and lesser numbers of Orophocrinus stelliformis. We collected one slab 8 by 11 inches on which no less than 14 specimens of Cryptoblastus melo are preserved on the upper surface. In the 10 feet of strata beneath the white ledge are to be found zaphrentid corals, fenestellid bryozoans, Batocrinus, Schellwienella, Chonetes, several species of Dictyoclostus, Rhipidomella, several species of Spirifer, Brachythyris, and several species of Platyceras and Igoceras. The presence of these particular gastropods may be correlated with the abundance of echinoderms, an association which has been noted several times and interpreted by some to mean that the gastropods lived on echinoderm refuse; a number of occurrences in which a gastropod is plastered over the anus of a crinoid have

been recorded. Lithologically the Orophocrinus zone in this quarry consists of brown to light gray, coarsely crystalline, crinoidal, dolomitic limestone. The overwhelming bulk of the rock is composed of crinoid and blastoid fragments in which the calcite has been only partially recrystallized. These fragments are imbedded in a matrix of fine grained yellow to brown dolomite. We visualize the crinoids and blastoids as growing in profusion in warm, clear, shallow waters with good circulation. In our opinion the fragmental nature of the dissociated pelmatozoan remains does not necessarily imply rough, violently agitated waters. The calyces of the camerate crinoids and the blastoids show little evidence of attrition, many fine details of ornamentation being preserved (see the unretouched photographs by Cline, 1936, 1937). We are not completely in agreement with our colleague and coworker L. R. Laudon, who has expressed the view orally and in writing that this type of limestone accumulates in a near shore zone where wave action shifts the crinoid fragments back and forth. The blastoids and crinoids appear too well preserved to have suffered such heroic treatment.

Ledges of pure, calcitic, crinoidal limestones in the upper part of the Burlington formation which have been extensively quarried in the vicinity of Springfield, Green County, in southwestern Missouri, abound in blastoids and camerate crinoids. In the cement quarries about three miles south of Springfield and near the fish hatchery, Orbitremites norwoodi and Pentremites elongatus are abundant in some of the higher levels. The limestone in which they occur is very light gray to white, pure, calcitic, non-dolomitic, and is composed almost entirely of echinoderm fragments. Cross bedding in some of the strata indicates that the echinoderm fragments were transported by currents and the abraded character of many of the blastoids would indicate that they were rolled about. Abandoned quarries in the upper Burlington in the town of Springfield and at Ash Grove a few miles to the northwest expose white crinoidal limestones of similar texture in which Orbitremites norwoodi and Pentremites burlingtonensis are abundant and Metablastus occurs sparingly. Hadrophyllum, Actinocrinites, Uperocrinus, Aorocrinus, Eucladocrinus, Dictyoclostus, Spirifer grimesi, Brachythyris, Platyceras, and Griffithides are associated with the blastoids.

Late Mississippian of Illinois, Kentucky, and Alabama.— Blastoids are quite common in the Meramec and Chester rocks of North America. We have collected large numbers of Mesoblastus glaber from a green calcareous shale seam in the Ste. Genevieve limestone at Cedar Bluff southeast of Princeton, Kentucky, and from equivalent hard gray limestone strata at Huntsville, Alabama.

Blastoids are so common in the Chester series that it has been referred to as the Pentremital and many individual strata referred to as blastoidal. The Paint Creek shale near Floraville, Illinois, and the Chester near Huntsville, Alabama, and many other localities, are famous for their well-preserved Pentremites. Chesterian rocks of Illinois, Kentucky, and Alabama are cyclical and offer outstanding opportunities for paleoecological studies. The nature of the cyclothems varies from area to area; in some areas they consist of alternating limestones and shales, each pair comprising a cyclothem; in other areas sandstone is a conspicuous element

in the cyclothem. Notwithstanding the obvious record of gradually changing environments reflected in the cyclothems, we have not discovered any noteworthy references to blastoid ecology. Blastoids occur in limestones in the Chester and in the interbedded and subjacent calcareous shales with which they are associated. We have not made population counts of the blastoids that we have collected and would hesitate to say whether they preferred a lime-forming environment to one of calcareous mud. We have actually collected far more blastoids from the shales than the limestones but this is because they are more readily freed from the shale by weathering, because the preservations are better, and because they are much easier to clean and prepare for study. Blastoids literally cover the upper surfaces of some limestone beds and vertical sections reveal that they are also present in the matrix but are less obvious. It might be argued that they preferred the limy environment and that sudden influxes of mud suffocated, smothered, and preserved them. One could point out that this would seem to be a logical explanation for the occurrence of a large number of calyces on the upper surface of a limestone where it is immediately overlain by shale and where the lower surface of the limestone is essentially devoid of blastoids. However, it would not explain the abundance of blastoids in calcareous shales in which there are no underlying limestones and this is a common occurrence.

Conclusions

1. Comparison with nearest living relatives.— The habits of the extinct blastoids probably were more nearly similar to those of the crinoids than to any other class of living echinoderms.

2. Fixation.— Blastoids almost certainly passed through a larval stage during which the larvae were planktonic or nektonic, and thus were capable of dispersion. Adult forms were affixed to a column or stalk of attachment composed of calcium carbonate discs bound together by an external covering of organic material. Although the stalk was flexible its main purpose was to raise and support the calyx above the sea floor and it was evidently incapable of active movement. Some forms may have freed themselves of their stalk so that they were free to move about like the Recent comatulid crinoids but there is no evidence for this in the great majority of the species. The character of the base of the calyx is ordinarily such as to indicate that it was attached up to the time of death. It is true that blastoids rarely have the stem preserved and one might argue that this is evidence that the adult forms were floaters. But blastoids just as rarely have the pinnules preserved. If adult blastoids detached themselves from the stalk and floated or swam about, such locomotion would have been accomplished by the pinnules and we would expect more commonly to find specimens with pinnules attached than those with stalk attached. The facts are that it is uncommon to find either stem or pinnules preserved and preservations with the stem seem to be as common as those with attached pinnules; if one of these structures is preserved, the other has a good chance of being preserved.

3. Explanation for the dissociated character of blastoid remains.— The observation noted in the above paragraph raises some interesting questions. Why are the stem and pinnules so commonly separated from the calyx and why are the plates comprising these structures so commonly dissociated? Did this fragmentation come about as the result of wave or current action either during or after death, did other organisms, i.e., fish, aid in their destruction, or was the fragmentation accomplished by other means? Most of the blastoid and crinoid remains seem to be those of mature individuals that probably died of natural causes. Upon death the decay of the epidermis and the bundles of muscles that bind together the stem, arm, and brachiole plates would permit the gradual dissociation of the calcareous components of these structures. The plates would then be subject to redistribution by currents but the fresh appearance of much of the debris of "crinoidal" limestones leads us to doubt that the fragments are ordinarily far removed from where the echinoderms lived and died. That violent wave action is not necessary to produce fragmentation of the stem and arms of echinoderms is indicated by some observations on modern crinoids by Clark (1915). In reporting on the response of crinoids to toxicity Clark describes how the arms began to break to pieces distally, the process continuing centripetally until the arms had completely disintegrated.

4. Salinity.— Blastoids were exclusively marine and seem always to have required waters of approximately normal salinity.

5. Temperature.— We can only guess at the optimum temperature and the temperature range for blastoids. The species commonly preserved in limestones presumably lived in warm carbonate-precipitating seas but other species may have lived in much colder waters.

6. Turbidity.— Because blastoids commonly are found in limestones it has been the general opinion that they required clear seas. In this paper we have cited a number of occurrences in which blastoids are abundant in calcareous shales, a condition that seems to be more general than is commonly realized. The presence of blastoids in shale does not prove that the water was continuously muddy; turbidity may have been intermittent and of short duration.

7. Character of bottom.— The stalk of attachment was probably anchored to a firm, rather stable bottom, and thus very soft muds and areas of shifting sands were apparently unfavorable.

8. Agitation of water.— Blastoids were dependent on circulating water for their food supply, so some current action is presupposed. The preservation of growth varies and fine details of ornamentation on many fossils would not lead us to believe that the environment of burial was one of violent surf action and we doubt that the environments of life and death were much more heroic.

9. Food.— Blastoids obtained their food directly from the water by means of ciliated furrows which lined the brachioles and communicated with the longitudinal food grooves on the calyx, and these in turn fed the food upward into the centrally located mouth. It seems likely that their

food was living vegetable plankton or organic detritus. Perhaps they, like Recent comatulids, had a diet consisting principally of unicellular green algae.

10. Gregarious nature.— A characteristic of echinoderms is that many species are gregarious. The abundance of blastoids at some localities and their absence in the same stratum a short distance away indicates that some species were gregarious. We do not see any evidence that colonies of blastoids inhabited the same locality long enough to form reefs. For example, a careful check of the occurrence of each specimen of a fine collection of blastoids that Laudon and Bowsher made from the Lake Valley formation of New Mexico reveals that nearly every specimen came from a non-reef portion of the formation.

11. Organic associations.— Crinoids and blastoids commonly are fossilized together and it is obvious that they were associated in life, and that their requirements were much the same. Cup corals, fenestellid bryozoans, and protremate and telotremate brachiopods are common associates in fossil communities, frequently outbulking the blastoids. Gastropods and trilobites are not uncommon but they do not equal the molluscoideans in number of species or number of individuals.

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1935. New species and some new occurrences of Middle Devonian blastoids: Buffalo Soc. Nat. Sci. Bull., vol. 17, no. 1, p. 26.

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JAPANESE PAPERS ON ECOLOGY AND PALEOECOLOGY

FOR THE PERIOD 1948-1951

by

Shoshiro Hanzawa and Kotora Hatai
Tôhoku University
Sendai, Japan

Asano, Kiyoshi
New Miocene Foraminifera from Japan: Jour. Paleontology, vol. 23, no. 4, pp. 423-430, 2 text figs., July, 1949.

The foraminifera from the Miocene Kokozura formation in Fukushima Prefecture, comprise planktonic forms such as Globigerinidae and Globorotaliidae, dominated by the Nodosariidae and Buliminidae. The latter families include neritic or deep water forms, indicating that the Kokozura formation is not a littoral or a shallow water deposit. The rare occurrence of the Miliolidae and Textulariidae confirm this interpretation. Sixty-eight species are listed and only new species are described.

Habe, Tadashige
Benthic Communities and Molluscan Thanatocoenoses of the Tanabe Bay: Bull. Japanese Scientific Fisheries, vol. 15, no. 5, pp. 238-244, 3 text figs., 1 table, 1949. (Japanese with English abstract.)

Detailed descriptions are given of conditions in the bay and distribution of the molluscan shells.

Habe, Tadashige
On the Ecological Distribution of Molluscan Shells in Tanabe Bay: Japanese Jour. Malacology, vol. 16, no. 1-4, pp. 13-18, Sept., 1950. (Japanese.)

Detailed descriptions are given of the distribution of the Recent molluscan shells found in Tanabe Bay. The shells are enumerated according to depth, locality and biocoenoses.

Habe, Tadashige
On the Ecological Distribution of Molluscan Shells in Tanabe Bay: Venus, vol. 16, no. 1-4, pp. 13-18, 1950. (Japanese.)

The horizontal and vertical distribution of the most common molluscan shells is briefly given. Benthonic shells are regularly distributed from interior to mouth, indicating a transition of variable densities of population. Proclava pfifferi, living in the interior of Tanabe Bay and in other bays around Kii Peninsula, is commonly represented in benthonic communities by empty shells.

Hanzawa, Shoshiro

Recent and Fossil Cycloclypeus from the Ryukyu Islands and their Adjacent Sea: Short Papers, Inst. Geology and Paleontology, Tohoku Univ., no. 3, pp. 1-12, pls. 1, 2, June, 1951.

Cycloclypeus guembelianus is described and a comparative morphological investigation of the fossil and Recent specimens presented. Ecological accounts of them are presented.

Hatai, Kotora

Coenozoic Mollusca from Aomori Prefecture, Japan: Jour. de Conchy Conchyliologie, Vol. du Centenaire, (vol. XC), pp. 128-136, 1 text fig., 1950.

Fossil molluscs from the Cenozoic formations of Yagen, Gamanosawa, Suganomata and Hamada in the Shimokita Peninsula, Aomori Prefecture are enumerated and the respective geological ages are also given. From faunal assemblages and climatic conditions and paleoecology are briefly stated.

Hatai, Kotora

Brachiopoda from Jizodo, Chiba Prefecture: Short Papers IGPS, no. 1, pp. 54-58, 1 text fig., July 5, 1950.

The present bathymetrical range of the six Pleistocene brachiopods together with their respective geographical distributions are given. The ecological conditions of the formations as indicated by the fossil fauna are presented. One new species is described.

Hayasaka, Ichiro

On Some Starfishes from Taiwan: Bull. Oceanographical Inst. Taiwan, no. 5, pp. 11-19, 3 pls., May, 1949.

Eight species of starfishes are reported, and their distributions off Taiwan, Ryukyu, the Caroline Islands, the Philippine Islands, Hongkong and Japan are tabulated. The bathymetric ranges and distributions are discussed as a basis for analysing fossil echinoid assemblages.

Ichikawa, Wataru

The Correlation of the Diatom-bearing Mudstones in the Noto Peninsula and the Vicinity of Kanazawa City: Jour. Geol. Soc. Japan, vol. 56, no. 653, pp. 48-56, 1950.

The diatom-bearing mudstones of Iizuka, Tsukada, Wakura, Awara, Hijirikawa and Mitsukoji are all marine and were deposited under cold currents. The Yamato mudstone is of brackish-water origin, in a partly enclosed bay. Besides diatoms, sponge spicules, Radiolaria, and Silico-flagellata were found. Dictyocha fibula and D. speculum are characteristic of cold waters.

Ichikawa, Wataru

The Fossil Diatoms in the Hirazawa diatomite, Miyagi-ken, Japan: (to be published in) The Science Repts. of the Kanazawa Univ., vol. 1, no. 2, pp. ca. 5, 1 pl., (about) July, 1951.

The vertical distribution of the fossil diatoms is represented by five beds with assemblages numbered IV from above downwards. This is considered to correspond to changes in ecological conditions in the course of sedimentation at this locality. Size variation of Cyclotella operculata is related to horizon differentiation. Most of the 33 species are freshwater types. Fresh-water types of diatoms are cosmopolitan in distribution but vary in assemblage from place to place laterally and vertically.

Ichikawa, Wataru

Geological Studies on the Diatomite in Japan: Jour. Geography, vol. 59, nos. 1-2, pp. 13-21, 3 text figs., 1950. (Japanese.)

Most Japanese diatomites occur in the Neogene Tertiary and are commonly found in the formations of the oil-fields of northern Japan. Distinct differences exist between marine and fresh-water diatomaceous deposits. Their origin, pelagic or limnic, is determined by studying the assemblages. Diatom beds serve as good key beds in stratigraphy, if the rock facies and floral compositions of the fossil diatoms are examined in detail. Diatomite deposits of commercial value exist in many places in Japan; these are mostly of fresh-water origin.

Ijiri, Shoji; Ogawa, Kennosuke; Takasawa, Matsuitsu; and Wada, Makota

Tertiary System in the Chichibu Basin: Bull. National Science Mus., no. 28, pp. 1-67, 1 geol. map, April, 1950. (Japanese.)

This is stratigraphical study of the Tertiary system developed in the Chichibu Basin. The formations recognized range from Oligocene to Middle Miocene, the Miocene beginning with Lepidocyclina and having a warm water fauna in contrast to the Oligocene which has a cool water fauna. Sedimentation and ecological discussions are presented in detail. The structure is also worked out.

Ishiwada, Yasufumi

Foraminiferal Death Assemblages from the Mouth of Toyama Bay: Bull. Geol. Survey of Japan, vol. 1, no. 4, pp. 1-13, 8 text figs., 3 tables, 1 pl., November, 1950. (Japanese with English abstract.)

The death assemblages of benthonic foraminifers are grouped into A-D. A is a typical Kuroshio fauna; B is transitional from A to C, but is characterized by Cassidulina; C is peculiar to the Japan Sea, both Recent and fossil; D is remarkably distinct probably owing to oligo-oxygen water. The vertical distribution of the assemblages corresponds to water mass and its vicissitudes and not to depth. Individuals transported from their own living places are not dominant in any assemblages under discussion. This is a preliminary report.

Iwabori, Shojiro

Tertiary Formation of the Toki Basin, Gifu Prefecture: Jour. Geol. Soc. Japan, vol. 56, no. 656, pp. 297, 298, May, 1950. (Japanese abstract only.)

Stratigraphical studies have determined that the Vicarya occupies a horizon higher than that of Operculina and Miogypsina. The molluscan shells from the Togari formation which occur together with Desmostylus do not represent cold water. The Ancistrolepis bearing horizon above that of Desmostylus represents the first invasion of cold water.

Kato, Kenji; Tanita, Sendai; and Okuda, Taizo
On the Water Properties and the Characters of Bottom Materials in Usu Bay: Scien. Papers of the Hokkaido Fisheries Scientific Institution, no. 8, pp. 39-68, 24 text figs., March, 1951. (Japanese with English abstract.)

The results of oceanographic and chemical investigations on the properties of water and bottom materials in Usu Bay are reported. In summer the percentage of the ignition loss and organic carbon contents of the bottom materials is noticeably higher than in winter, while the average nitrogen content remains almost unvariable. The water properties and bottom characters of the bay seem to be favourable to the culture of oysters.

Kato, Kenji; Tani, Sendae; and Okuta, Taizo
Studies on the Environmental Conditions of Shell-fish-Fields. 11. The Case of Muroran Harbour: Bull. Fisheries Dept., Hokkaido Univ., vol. 1, no. 2, pp. 66-76, 13 text figs., February, 1951. (Japanese with English abstract.)

Oceanographic, chemical and bottom materials are investigated with the view to determining the cause of the decrease in shell-fishes in the harbour.

Kawai, Kozo; Takayasu, Uchio; Ueno, Michifumi; and Hozuki, Mitsugoro
Natural Gas in the Vicinity of Otaki, Chiba Prefecture: Jour. Japanese Assoc. Petroleum Geologists, vol. 15, no. 4, pp. 151-219, 1950. (Japanese with English abstract.)

The stratigraphy, geologic structure, lithology, and faunal lists from each of the 27 zonules are given together with brief accounts on the oceanographic conditions under which the fossil faunas once lived.

Kotaka, Tamio
Paleogene Turritella of Japan: Short Papers IGPS, no. 1, pp. 32-41, pl. 5, July 5, 1950.

The genus Turritella is treated systematically and the stratigraphic and ecological significance of the genus and of the Japanese species are set forth.

Kubo, Ikuso
Studies on the Penaeids of Japan and its Adjacent Waters: Jour. Tokyo Coll. Fisheries, vol. 36, no. 1, pp. 1-467, 1949.

Sixty-seven species and 1 sub-species referable to 16 genera and 4 sub-families are described and figured; two genera and 21 species are new. The material is from various localities off Japan, the Chusan Islands, East China Sea, Hainan Island, Thai, Borneo and the Celebes. This is the standard work for scientists on the Penaeids of the western Pacific.

Maruhashi, Masaho
Foraminiferal fauna of Tokyo Bay: Miscellaneous Rept. of the Res. Inst. for Natural Resources, no. 12, pp. 37-41, 1948. (Japanese.)

Various stations were selected in Tokyo Bay and the foraminiferal content of each was determined. The following assemblages were recognized: namely, Quinqueloculina-Lagena, Rotalia and Ammoglobigerina-Rotalia. The content and distribution of each of the assemblages is described. Comparative studies are made with the assemblages occurring in the bays previously studied and reported by former workers.

Maruhashi, Masaho
Foraminiferal Fauna of the Tokyo Bay: Misc. Rept. Res. Inst. for Natural Resources, no. 12, pp. 37-41, 5 text figs., 1948. (Japanese.)

The proportion of benthic and pelagic foraminifera occurring in an assemblage are analysed and compared with assemblages of other nearby bays.

Maruhashi, Masaho
On the Foraminiferal Fauna of the Cenozoic Formations in the Vicinity of Choshi, Chiba Prefecture: Misc. Repts. Res. Inst. Natural Resources, no. 12, pp. 42, November, 1948. (Japanese.)

Zoning and environment of the sediments of the Iioka and Toyosato formations are studied from the contained foraminiferal fauna. Four assemblages representing shallow and deep water forms are distinguished throughout the formations. The shallow water foraminiferal faunas agree both with the lithological characters of the formations and also with the molluscan fossils in association.

Minato, Masao
Recent Geological History of the Surrounding Area Lake Abashiri in Hokkaido: Rept. Geology of Hokkaido, no. 13, pp. 6-10, 1 text fig., March, 1950. (Japanese.)

From the stratigraphy and occurrence of marine and fresh-water fossil molluscs, the area surrounding the lake can be divided into four periods; namely the ages of Paphia, Ostrea, Corbicula and Anodonta, all referable to the Quaternary. This shows that the conditions changed from marine, to brackish water to freshwater.

Miyadi, Denzaburo; Habe, Tadashige; Kawaguti, Masao; and Yamazi, Isamu
Benthonic Biocoenoses and Thanatocoenoses of the Maizuru Bay: Studies on the Aquatic Animals of Japan, vol. 1, pp. 33-43, 2 text figs., 9 tables, 1950. (Japanese with English abstract.)

The results of a benthonic survey of Maizuru Bay carried out in May 1946, are presented. Its morphological features characteristic of strong embayment have definite influences not only on the benthos but also on the nekton.

Miyadi, Denzaburo; Habe, Tadashige; and Yamazi, Isamu
On the Benthos and Shell-deposits of Kumihama Bay, a Lagoon on the Southwestern Japan Sea Coast: Studies on Aquatic Animals of Japan, vol. 1, pp. 25-32, 3 text figs., 3 tables, 1950. (Japanese with English abstract.)

Kumihama Bay, a lagoon on the Japan Sea coast, dammed up by sand bars, was surveyed on June 22, 1947. The impoverished benthonic fauna as well as the molluscan thanatocoenoses of the bay may be due to its stagnant hydrological condition. This is suggested by the wider appearance of an azoic area in the central region of its main basin in the advanced summer season.

Miyawaki, Miharu
Notes on the Effect of Low Salinity on an Actinian, Diadumene luciae: Jour. Faculty of Science, Hokkaido Univ., ser. VI, vol. 10, no. 2, pp. 123-126, 3 text figs., March, 1951.

Murata, Sigeo
On the Paleo-ecological Investigation of the Fossil Foraminiferal Fauna in the Miyazaki Group, with Description of New Species: Bull. Kyushu Inst. Tech., no. 1, pp. 91-104, 1 text fig., March, 1951.

Results of paleoecological investigations of the foraminifera reveal that the climatic conditions of the upper Miocene Miyazaki group were warmer than at present at the same latitude, and also warmer than that of the Pliocene. Cyclammina is restricted to open sea conditions. Zonules were established for each stratigraphic section and range charts were compiled for the foraminifers of the Miyazaki group.

Nagahama, Masaho
Studies on the Foraminiferal Fauna of Small or almost Enclosed Bays in Japan: Misc. Repts. Res. Inst. Natural Resources, nos. 19-21, pp. 142-148, 1951. (Japanese with English abstract.)

This paper deals with the foraminiferal fauna of certain small or almost enclosed bays, such as Beppu, Matsunaga, Ise and Kagoshima. The faunal groupings based upon the genera coincide with those of the species. These faunas are divided into several types: Bulimina-Eponides type, which represents deep water at the transitional zone with the open sea; Rotalia-type, which includes several faunas associated more or less with Eponides, Quinqueloculina, Elphidium, etc.,

and representing shallow water. Such differences in distribution are intimately connected with the salinity, temperature and depth of water. The total number of individuals seems to be regulated by the oxygen content of the water.

Nakaseko, Koziro and Sawai, Kiyoshi

Foraminiferal Fauna of the Nakatsu Formation (Microbiostratigraphic study of the Cainozoic strata of Japan, ser. 1): Jour. Geol. Soc. Japan, vol. 55, no. 650-651, pp. 205-210, 2 text figs., Nov.-Dec., 1949. (Japanese with English abstract.)

In the control section of the Nakatsu formation, the foraminiferas occur in two zones, of which the upper is further divided into five zonules. The fauna of the upper zone includes species known from the shallow water of northern Japan. Details of the paleoecological significance of the foraminifera are given.

Niino, Hiroshi

On the Bottom Deposits on the Banks at the Mouth of Wakasa Bay and on the Adjacent Continental Shelf: Jour. of the Tokyo Univ. Fisheries, vol. 37, no. 1, pp. 1-274, 38 tables, 65 text figs., 3 pls., 1950. (Japanese with English abstract.)

Bottom samples were procured from 623 stations in the bay. Each station is analyzed as to its lithological and petrographical characters and organic remains. From the analyses and the data on distribution, submarine configuration, oceanic currents, supply of sediments from rivers and geology of the coastal land, it is inferred that post-Tertiary crustal movement served to isolate the banks of Urashima, Gentatsu, Matsudashi, Oguri and others from the mainland.

Oyama, Katsura

A Consideration on Vicarya and Marine Transgressions: Jour. Geol. Soc. Japan, vol. 55, nos. 648-649, p. 176, Nov.-Dec., 1949. (Japanese abstract only.)

Vicarya is a brackish water genus of the Potamidae and flourishes in bays. It indicates warm water and transgression.

Oyama, Katura

Studies of Fossil Molluscan Biocoenoses No. 1, Biocoenological Studies on the Mangrove Swamps, with Description of New Species from the Yatuo Group: Rept. Geol. Sur. of Japan, no. 132, pp. 1-16, pls. 1-3, 1 text fig., 1950.

Biocoenoses of mangrove swamps in the tropics and subtropics are first described, and then related to the Lower Miocene Kakebata formation of the Yatuo group. The assemblage is called the Telescopium-Geloina biocoenoses.

Oyama, Katura

On Mollusca Dredged from off Kumaisi with Notes on Rise and Fall of Ocean-Current: Misc. Repts. Res. Inst. Natural Resources, nos. 19-21, pp. 137-141, 1 table, February, 1951. (Japanese with English abstract.)

Molluscan faunas dredged from off Kumaisi include several elements. Stenothermal warm elements make up simple subneritic or mesoneritic biocoenosis; eurythermal and stenothermal cold elements are euneritic to subneritic sand biocoenoses. This mixture may be easily explained by considering the rise and fall of coastal water and ocean-current. There are many paleontological examples to be explained in this manner.

Shimomura, Toshimasa

On the Time Variation of the Constitution and Quantity of Plankton in Ocean: Jour. Oceanographical Soc. Japan, vol. 5, nos. 2-4, pp. 93-99, 1950. (Japanese with English abstract.)

Investigations were carried out on the variation with season, day, time and place of the constitution and quantity of plankton in the north-west Pacific Ocean. It was found that the distribution of Plankton varies widely with time and place also in an ocean as neritic region. If the Plankton-distribution is to serve as an indicator to water mass or productivity of a sea district, it is necessary to collect data from many research stations.

Takayanagi, Yokichi

Pliocene Smaller Foraminifera from Western Sendai: Short Papers IGPS, no. 2, pp. 23-28, 1-6 text figs., Dec. 15, 1950.

Six zones are recognized within the Pliocene Tatsunokuchi formation and their micro- and macro-faunas are analysed. The smaller foraminiferal fauna probably flourished in a biotope distinct from that of the molluscs. Emphasis is laid on bottom control, ecologic and oceanographic conditions. Two new species are described.

Tanita, Senji; Kato, Kenjiro; and Okuda, Taizo

Studies on the Environmental Conditions of Shellfish-Fields. 1. In the Case of Hakodate Harbour: Bull. Fisheries Dept., Hokkaido Univ., vol. 1, no. 1, pp. 1-10, 7 text figs., February, 1951. (Japanese with English abstract.)

To determine the cause of the near extermination of shellfishes in Hakodate bay, oceanographic investigations were conducted based upo chemical and physical studies of the sea water, bottom materials general configuration in relation to surface and bottom currents.

Tokioka, Takasi and Yamazi, Isamu

Qualitative Distribution of Plankton in Ago Bay: Kyoto Univ. Papers in Physiology and Ecology, nos. 70-71, pp. 5-18, 19-61, 20 text figs., 129 tables, 1950. (Japanese.)

Plankton surveys were made in the bay during June 1946, Sept. 1946, Feb. and Aug. 1947 to determine the effective limit of oceanic influx. Quantitative and qualitative analysis of the plankton, detailed compositions of diatoms, dinoflagellates, protozoans, copepods, larvae and other animal forms in each area of the bay were compared carefully with one another. Plankton seem to be most abundant in areas where the oceanic water and the stagnant baylet water are mixed actively.

Tokioka, Takasi

Notes on the Development of the Eye and the Vertical Distribution of Chaetognatha: Nature and Culture, no. 1, pp. 117-132, 2 text figs., 2 tables, 1950. (Japanese with English abstract.)

Chaetognaths develop a tendency to enlarge their eyes and probably, to increase the function of the eye till they reach ca.200-500 m. depths, where their pigment flecks begin to degenerate and at last the function of the eyes seem to be lost on inhabitants (Sagitta macrcephala) in the permanent darkness of the depths of 500 m or more.

Tsubata, Fumitaka

On the Distribution of Diatoms off the South-East Coast of Hokkaido with Considerations of Hydrographic Conditions: Jour. Oceanographical Soc. Japan, vol. 6, no. 2, pp. 33-38, 1950. (Japanese with English abstract.)

For the purpose of investigating the distribution of Diatoms during October to November 1947, the southeast coast of Hokkaido was divided into five regions, each characterized by its own diatom flora. Considering the hydrographic conditions of these regions, it was found that oceanic currents, whether warm or cold kept to their own area and had their own particular flora.

Uchio, Takayasu

Tertiary Fossil Fauna from Tochigi Prefecture (1): Jour. Geol. Soc. Japan, vol. 56, no. 661, pp. 455-458, 3 tables, October, 1950. (Japanese with English abstract.)

The Tertiary deposits are divided into three formations. The fossil fauna from each of the formations is discussed and the environment under which they were deposited and the thermal conditions then existing are presented. The geology is described. The formations range in age from Middle to Upper Miocene. All are marine.

The microfauna indicates that the Momiyama sandstone was influenced by not typically warm shallow water as is shown by the co-existence of warm and cold water elements. The micro-fauna of the Terayama group suggests a middle neritic environment. The Fauna formation contains plant fossils indicating a mild, climatic forest although some warmer elements are intermingled.

Utinomi, Huzio
Ecological Division of Intertidal Biocoenoses based on the Types of Habitats: Kyoto Univ., Papers on Physiology and Ecology, vol. 4, nos. 1-2, pp. 50-59, 1950. (Japanese with English abstract.)

Gislén's classification of marine biotic communities based on difference of situation occupied by the organisms on substratum seems to be insufficient so far as the intertidal communities are concerned. It may be subdivided into three types according to degree of desiccation and immersion as well as to the relation to the substratum: xerobiose, hygrobiose and hydrobiose. The habitat of intertidal communities must be formed by the combination of types, based on their relation to the substratum and on the degree of desiccation. The xer- and hydro-bioses are comparatively stable, while the hygrobioses is unstable and usually combined with the hypobiose. These habitat types are not innate to any organism but may vary according to localities and microclimatic conditions. The vertical zonations of natural habitats are not always parallel to the tidal levels.

Utinomi, Huzio; Yamazi, Isamu; and Ikari, Miho
Topographical and Tidal Conditions as Environment Factors. 2-Meterological and Hydrological Conditions as Environmental Factors. 3-Biota of Tide Pools, their Composition and Fluctuation: Kyoto Univ. Paper in Physiology and Ecology, nos. 66-68, pp. 1-5, 3 text figs., 6 tables, pp. 6-14, 4 text figs., 6 tables, pp. 15-23, 2 text figs., 4 tables, 1950. (Japanese with English abstract.)

To investigate the relation of the biocoenoses of tide pools to certain environmental factors, periodical observations were made on a series of seven tide pools on the abrasion rocks at Bansyozaki, Tanabe Bay, during a year, from 1948-1949. These seven tide pools can be roughly divided into two or three groups topographically, hydrologically and synecologically. Details are presented.

Watanabe, Kagetaka; Arai, Juzo; and Hayashi, Tadaichi
Tertiary Geology of the Chichibu Basin: Repts. of the Chichibu Natural Sci. Mus., no. 1, pp. 29-92, pls. 1-6, 17 text figs., 1 geol. map, 1951. (Japanese with English abstract.)

The Akahira group, divided into three formations, lies unconformably upon pre-Tertiary rocks and contains invertebrate fossils suggesting cold water and an open sea assemblage in strong contrast to the overlying Chichibu-machi group, which is divided into four formations and contains tropical foraminifers and molluscs.

Yamamoto, Gotaro
Ecological Note on Transplanatation of the Scallop Pecten yessoensis Jay, in Mutsu Bay, with Special Reference to the Succession of the Benthic Communities: Science Repts. Tohoku Univ., 4th ser., Biology, vol. 19, no. 1, pp. 11-16, 1951.

Yamamoto, Gotaro

Ecological Studies on the Cultivation of the Scallop in Mustu Bay, with Special Reference to the Succession of Benthos: Ecological Review, vol. 13, no. 1, pp. 1-4, 4 text figs., 1951. (Japanese.)

Yamazi, Isamu

Plankton Investigation in Inlet Waters along the Coast of Japan. 1. Introductory Notes and the Plankton of Akkeshi Bay, Hanasaki Inlet and Nemuro Harbour: Publ. Seto Marine Biol. Lab., vol. 1, no. 3, pp. 93-113, 14 text figs., 19 tables, 1950.

The plankton was investigated quantitatively and qualitatively and details of its distribution in relation to hydrological conditions are presented.

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LIST OF REPORTS IN THIS SERIES *

No. 1 - Report of Subcommittee on the Ecology of Marine Organisms, 1940-41. 1st edition, Nov. 1941; 2nd ed., July 1944. 51 pages. $0.50.

No. 2 - Report of the Committee on Marine Ecology as Related to Paleontology, 1941-42. Dec. 1942. 58 pages. $0.50. (Reprinted June 1949)

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The present Annual Report (No. 11) will probably be the last of this series, and it is expected that the Treatise will be submitted to the publisher during 1952.